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THE SANITARY ENGINEERING PROBLEMS OF WATER SUPPLY AND SEWAGE DISPOSAL IN NEW YORK CITY[1]

THE Section on Public Health of the New York Academy of Medicine is formed at a peculiarly opportune time. Never before has sanitary information of a reliable, authentic character been so much desired by the public, nor so difficult for the public to obtain.

Our great universities have, for the most part, failed to recognize the vast popular and educational value which would attach to the establishment of adequate facilities for teaching sanitary science, hygiene, public health or preventive medicine, as that body of knowledge which relates to the prevention of disease is variously termed, and have left this kind of teaching largely to the newspapers and to the general practitioner of medicine. Unfortunately, physicians do not always appreciate their importance as sanitary teachers.

It is in consequence of this that vast stores of scientific facts which are being constantly collected, and which bear upon the causes and ways of preventing disease,

[1] Address delivered at the opening of a Section on Public Health of the New York Academy of Medicine, January 8, 1907.

are locked up in severely technical journals or brought out, often with an entirely mistaken interpretation, in the public press.

Aside from the collection of new sanitary facts, therefore, the members of this section can perform an extremely valuable service in assimilating the data made available by scientists and other busy workers and help to mold public opinion toward a proper consideration of the endless number of topics which relate to the public health.

The beneficial fruits of these labors will certainly be far-reaching. It has been well said that the eyes of the whole country are upon the metropolis. To a considerable extent what is found to be good here is likely to be thought desirable elsewhere.

At the initiation of this section, it may be well to take a brief glance at some of the larger sanitary engineering problems which now concern New York and consider how, in view of present and future circumstances, these problems should be studied.

We have in New York a singularly good example of a city of the largest class, wherein the highest requirements of sanitation are demanded and are, at the same time, capable of being satisfied. The population is not only great; it is concentrated, and in race, habit and social condition, exceedingly diverse. Practically all of the conditions necessary to maintain life in a wholesome way have to be secured through a most careful observance of sanitary rules and principles. This relates not only to the food, clothing and habitations of the people, but in a peculiar degree to the care of their wastes and the wastes of those who have to do with the city's food and drink. Upon the prompt and adequate disposal of these wastes largely depends the security of the city against disease.

These, in the briefest terms, appear to be the necessities of the present. What the exactions of the future will be, when more refined standards of hygiene are established and the public sense of decency and morality becomes correspondingly elevated, it is impossible to say. It is evident that the subjects which are to concern our future guardians of public health are not to be related solely to the more obvious causes of disease.

Thus far, in the history of sanitation, the great strides of progress have usually resulted from emergencies, most of which have pointed in a striking manner to the fact that the grosser human wastes were not being properly dealt with. Unfortunately this method of progress still prevails to a great extent through the country, as witness the large quantities of filth of all kinds which accumulate in our northern villages and cities through the winter and the epidemics of typhoid fever which occur every year.

Sanitary emergencies, such, for example, as infected water supplies, capable of producing epidemics, now rarely occur in our largest centers of population and are no longer to be expected in the city of New York, which rightfully boasts one of the most efficient health administrations known anywhere.

Sanitation in cities of this class now and in future may be expected to progress along more scientific and conservative lines. The conditions to be avoided must be discovered and corrected as far as possible before they result in nuisance or disease. Large schemes for sanitary improvement must be made and made after careful investigation and preparation while yet there is ample time.

Two large sanitary engineering problems which now confront the city of New York are being studied in this manner, and as they well illustrate what is meant by these remarks, they will be briefly referred to.

The water supply is being enlarged.

Competent authorities have studied the matter exhaustively and decided upon what it is best to do. This problem has now entered upon its second stage, that of construction.

The project is, as you know, to enlarge the supply of all the boroughs of the city by bringing water from the Catskill Mountains. The quantity to be delivered will be from 80,000,000 to 150,000,000 gallons per twenty-four hours at first, and will probably reach 500,000,000 gallons, or more, in time. It is estimated that this, with the present sources of supply, should be enough to meet the needs of the increasing population until 1925. The present supply of Croton, which is consumed in Manhattan and Bronx, is about 292,000,000 gallows per day with a per day increase each year of 14,000,000 gallons, as shown by the records of consumption for the last ten years.

The quality of the new water will be superior to that of the Croton. It will be softer to begin with, and will be filtered through slow sand filter beds, located near White Plains, such as have been extensively used in various parts of Europe and America for many years. It is practically certain that the Croton supply will be filtered in the same manner.

Although a part of the new water will be available for the boroughs of Brooklyn and Staten Island, it is considered highly desirable that Brooklyn, if possible, should avail itself of supplies now stored in the sands of Long Island east of the present sources of supply.

As pointed out by the mayor, in his message of January 7, 1907, since the New York Board of Water Supply was appointed in June, 1905, remarkable progress has been made by its engineers in the preliminary work necessary to construction. About 40 per cent. of the line of the principal aqueduct of 86 miles from the Catskills to what is known as the Hill View reservoir, located near Yonkers, has been located, as has the site of the dam for the great Ashokan reservoir and the 10,000 acres of the reservoir itself. About 15 per cent. of this aqueduct has been prepared for contract. To accomplish this result, 550 miles of surveys and 12 miles of subsurface borings have been made.

At this rate of progress, it would not be surprising if water from this new source would be available considerably within the eight years allowed by the engineers.

As pointed out by the mayor, the new water supply is to cost over $160,000,000 and it is highly desirable that the taxpayers should understand the benefits to accrue from it.

The need of this work did not arise from any emergency. No epidemic pointed to its necessity. The work is being carried out largely in anticipation of the needs of the future, as pointed out with infallible accuracy by the teachings of sanitary science.

The problem of disposing of the sewage of New York and neighboring municipalities so that it shall not create a nuisance, or in other ways interfere with health, comfort or convenience has been the subject of official study for three years and is likely to continue to be investigated for several years to come. And the question here is not so much to improve present conditions, although this object may be accomplished in the end, as to protect our tidal waters against the vastly increasing pollution of the future.

Hitherto there has been no question as to the efficacy of the method of sewage disposal pursued by New York and its neighboring municipalities. House sewage and street washings have been discharged, without purification of any kind, into the nearest tide waters. Recently, communities remote from the shore have joined together

to bring their combined sewage through miles of sewers to the bay. One of these projects is unprecedented in the quantity of sewage to be carried. By a curious coincidence, the contemplated point of discharge is near the statue of Liberty Enlightening the World.

To say the least, it is disquieting to contemplate the discharge of so much potential danger into the waters which flow by our doors; which so many of us cross and recross daily; which is the scene of many of our most imposing national and municipal pageants; where some of us bathe—and many of us get our oysters.

If the wastes are rendered innocuous, they are destroyed in ways which are not understood. Our knowledge of the fate of the sewage of New York may be said to extend no farther than the outfalls of the sewers.

It is unwise to count blindly upon the purifying action of sea water and the tides, for to what extent the flow of the ocean in and about the great rivers and harbors which intersect the metropolitan district transports and renders innocuous the five hundred million gallons of dangerous matters which are discharged into them every day, it is impossible to say.

Perhaps the sewage is flushed out to sea; perhaps it is consumed by minute animals and plants; perhaps some of it is turned into gas, some into liquids, some oxidized or burnt up by the nitrifying bacteria in the water. Perhaps much of it is stored in pockets and sludge banks until freshets in the Hudson flush it out to sea. We do not know what becomes of it.

Obviously, the harbor, as a whole, has a large digestive capacity for sewage, but it would be curious, indeed, if that capacity had no limit. There are few persons who have been actively interested in studying this problem who do not consider that eventually some other method of sewage disposal than the present one will be necessary for a large part of the Metropolitan District. It is only a question of time. How long, nobody knows.

These two questions, the supply of pure water and the disposal of this water after it has been turned into sewage are sanitary problems of the largest kind. The estimated cost of constructing the new water works of New York exceeds the estimated cost of building the Panama Canal. If it becomes necessary to collect and purify all of the sewage of the metropolitan district, it may be a costlier task still.

The highest skill, wisdom and efficiency are none too great to enlist in devising safe and suitable works of such magnitude. The sciences of pathology, chemistry, biology, physics, meteorology and mechanics must contribute generously to the fund of information necessary in order that the plans may be brought to that high point of perfection which engineers characterize as 'necessary and sufficient' in their works.

And there is another consideration which has, so far, received little thought, but which must be taken into account in dealing with the sewage disposal problem. For work to be done at all, it must be done within permissible limits of cost. The charter of New York, which intentionally omits to restrict expenditures for water supply, confines the cost of sewerage and sewage disposal to within the constitutional debt limits of the city.

In thus giving emphasis to two of the problems which New York is attempting to solve, it is not intended to draw attention from other sanitary engineering problems, some of which are of almost equal prominence.

The double problem of cleaning the streets and disposing of the wastes so collected is one of the greatest magnitude. It costs the city over $6,000,000 per year to

maintain the department of street cleaning. In no other comparable city in the civilized world is this question in such unsatisfactory shape or so difficult to cope with, under the practical conditions which exist, as in the metropolitan district which we are considering.

The time will come when New York City will insist upon clean streets and find a way to have them. Eventually the public will demand that the refuse from our tables, kitchens and factories shall be disposed of at a minimum of offense and a maximum of economy and despatch. But until this problem is made the subject of competent study and a broad, comprehensive plan of administration and procedure is laid down, we may expect slow improvement in the primitive methods which have always been an offense to the eyes and nose in New York City.

The solution of this problem is probably far beyond the unaided capacity of any person who may be placed at the head of the street-cleaning department, and these remarks, therefore, reflect in no wise upon the ability of any official of the city, past, present or future. If it can be solved at all, and there is a very general impression that it can, the problem can be solved only as the other great sanitary engineering problems of New York have been, and are being, solved. That is, with the help of qualified experts, acting without prejudice, political bias or other ambition than to serve the best interests of the city.

George A. Soper

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE SECTION A—MATHEMATICS AND ASTRONOMY

Vice-president—Dr. Edward Kasner, Columbia University, New York City.

Secretary—Professor L. G. Weld, State University of Iowa, Iowa City, Iowa.

Member of the Council—Professor G. B. Halsted, State Normal College, Greeley, Colorado.

Sectional Committee—Dr. Edward Kasner, vice-president, 1907; Dr. W. S. Eichelberger, vice-president, 1906; Professor L. G. Weld, secretary, 1904–1908; Professor Ormond Stone, one year; Professor E. B. Frost, two years; Professor E. O. Lovett, three years; Professor Harris Hancock, four years; Professor A. N. Skinner, five years.

Member of the General Committee—Professor James McMahon, Cornell University, Ithaca, N. Y.

Press Secretary—The secretary of the section.

Professor E. O. Lovett, of Princeton University, was elected vice-president for the year 1908.

The following mathematicians and astronomers were elected to fellowship in the association:

Baker, R. H.,	Maclay, James,
Brown, G. L.,	Manning, H. P.,
Dugan, R. S.,	Olds, G. D.,
Faught, J. B.,	Plimpton, G. A.,
Gates, Fannie C.,	Poor, C. L.,
Glenn, O. E,,	Riggs, N. C.,
Graham, W. J.,	Schultz, L. G.,
Granville, W. A.,	Smith, F. H.,
Hadley, S. M.,	Washburne, A. C.,
Leavitt, Henrietta L.,	Wilson, N. R.,
Lowell, Percival,	Young, Anna S.

The address of the retiring vice-president, Dr. W. S. Eichelberger, entitled 'Clocks, Ancient and Modern,' was presented on the afternoon of Thursday, December 27, in Fayerweather Hall of Columbia University. This address has already been published in Science for March 22 of the current year.

A joint session of Section A with the American Mathematical Society and the Astronomical and Astrophysical Society of America was held on Friday forenoon, December 28, in Schermerhorn Hall. The chair was occupied by Professor Simon Newcomb, past president of each of the participating societies. This was perhaps the most largely attended and the most generally interesting of any of the meetings in which any of the participating societies had a part. The following program was

presented: numbers 1 and 5 being contributed by the Mathematical Society, 2 and 4 by the Astronomical and Astrophysical Society, 3, 6 and 7 by Section A.

1. *The Rational Basis of Mathematical Pedagogy:* Professor S. E. Slocum, University of Cincinnati.
2. *Photographic Observations of the Milky Way:* Professor E. E. Barnard, Yerkes Observatory.
3. *The Stream Function for a Straight Channel with a Circular Island:* Professor James McMahon.
4. *The Tenth Satellite of Saturn:* Professor W. H. Pickering, Harvard University.
5. *On the Law of Gravitation in the Binary Systems:* Dr. F. L. Griffin, Williams College.
6. *Latitude Terms of Long Period:* Professor C. L. Doolittle.
7. *Dynamical Trajectories:* Dr. Edward Kasner.

Abstracts of 1 and 5 of the above papers appear in the *Bulletin of the American Mathematical Society,* Vol. VIII., pp. 265, 266; of 2, 4 and 6, in the report of the eighth annual meeting of the Astronomical and Astrophysical Society of America, in Science for April 12. The others will be further noticed below.

The full list of papers appearing upon the program of Section A, with such abstracts of the same as are available, is as follows:

An Examination of the Results of Seven Years' Observation with the Zenith Telescope of the Flower Observatory for Latitude Terms of Long Period: Professor C. L. Doolittle, University of Pennsylvania, Philadelphia.

A Preliminary Report on a Solar Rotative Period Investigation: Mr. Philip Fox, Yerkes Observatory, Williams Bay, Wis.

The preliminary investigation of the solar rotation period which was made, under Mr. Hale's direction, by measuring calcium flocculi positions on the Kenwood series of spectroheliograms (Science, N. S., XXI., 175), is now being supplemented by a reduction of the measurements of the plates made with the Rumford Spectroheliograph. One hundred of these plates obtained in 1904 give the following results:

ϕ	ξ	Rumford Period	Kenwood Period	$R-K$
° °	°	d	d	d
0 5	14.50	24.82	24.56	+0.26
5 10	14.44	24.93	24.79	0.14
10 15	14.18	25.38	25.02	0.36
15 20	13.92	25.86	25.26	0.60
20 25	13.68	26.32	25.45	+0.87
25 30	13.95	25.80	25.99	—0.19
30 35	13.68	26.31	26.31	0.00
35 40	13.25	27.18		

The periods are thus seen to have been longer in 1904 than in 1893–4–5, the period covered by the Kenwood series. The plates of 1905 and 1906 are about to be measured.

The Retrograde Motion of Phœbe: Mr. A. O. Granger, Philadelphia, Pa. (Read by title.)

The Sect-carrier and the Set-sect: Professor G. B. Halsted, State Normal College, Greeley, Colo.

The school of Plato fixed as the instruments for the solution of geometric problems, the ruler and compasses, the straight line and circle. As in Euclidean geometry the straight line is a circle (of infinite radius) and as Euclid unconsciously made in his very first proposition the 'assumption of the compasses,' that "If a circle have a point within and a point without another circle, it has two points on this other" (Halsted, 'R. Geom.,' VI., 2), the world has had to await the coming of the non-Euclidean geometry to become conscious of the fact that elementary geometry has been carrying a wholly unnecessary 'rider.'

The compasses may be superseded by the simpler 'transferrer of line-segments,' for which the name 'sect-carrier' has been adopted. Thus without the circle or compasses all the problems of elementary geometry are solved in the first edition of Halsted's 'Rational Geometry.' But a remarkable additional simplification has now been achieved, and this paper makes public for the first time the simple demonstration which makes it available for the elements of geometry. This advance is the substitution of the set-sect for the sect-carrier. The transference of only a single sect need be assumed for the solution of all the problems of elementary geometry. Consequently the power to take a centimeter on a given straight line is found to be assumption enough to supersede the circle, the compasses, and even the sect-carrier. Nothing now is needed but a ruler and a set-sect.

On a Fundamental Theorem of Weierstrass by Means of which the Theory of Elliptic Functions may be Established: Professor HARRIS HANCOCK, University of Cincinnati, Cincinnati, O.

The theorem in question is stated by Weierstrass in the 'Theorie der Abelschen Functionen' (*Crelle's Journ.*, bd. 52, § 7; and 'Math. Werke,' bd. I., p. 349).

By means of his theorem it may be shown that the *p*-function may be expressed as the quotient of two series which are both convergent for all values of the variable; the same is true of the functions

$$\sqrt{p\omega - e_\lambda} \qquad (\lambda = 1, 2, 3).$$

It follows directly from Weierstrass's theorem that the σ-function may be expressed as a convergent series for all values of the variable.

The different series are calculated and it is interesting to compare the results usually obtained from the well-known theorem also due to Weierstrass, that *every one-valued function that has not an essential singularity in the finite portion of the plane, may be expressed through the quotient of two power-series, which are convergent for all values of the variable.*

Weierstrass's theorem is also generalized and applied to differential equations of a higher order.

Dynamical Trajectories: DR. EDWARD KASNER, Columbia University, New York City.

Professor Kasner discusses two general questions, of interest in connection with celestial mechanics, relating to the geometry of dynamical trajectories. The first is suggested by the problem of binary stars and Bertrand's discussion of the interdependence of Kepler's laws. It is shown that two distinct fields of force can have only a certain multiplicity of trajectories in common. It is then possible to determine a field from a minimum number of trajectories. In particular, the Newtonian law may be deduced without assuming, as Bertrand does, that all the orbits are conics.

The second part of the paper relates to the problem of n bodies, and extends some of the results which hold for a single particle (see *Trans. Amer. Math. Soc.*, 1906, 1907). For example, the locus of the centers of the osculating spheres, under prescribed initial conditions, is a cubic curve; in the case of a single particle, on the other hand, it is a straight line. The results obtained are true for all interacting particles.

The Stream Function for a Straight Channel with a Circular Island: JAMES MCMAHON, Cornell University, Ithaca, N. Y.

This is one of the standing problems in two-dimensional fluid motion. A solution is here obtained by imagining a doublet placed mid-stream in a uniform current so that the line from the source to the adjoining sink points in the direction of the undisturbed current. The appropriate stream

function is determined to suit the boundary conditions, by the image-method; and it is shown that one of the stream lines breaks up into the median line of the channel and a symmetrical oval. The strength of the doublet can be so adjusted that this oval does not differ appreciably from a given circle when the latter does not occupy more than half the breadth of the channel.

Preliminary Wave-lengths of Flash Spectra taken in Spain, August 30, 1905: Dr. S. A. MITCHELL, Columbia University, New York City.

The wave-lengths were obtained from photographs taken by the writer while a member of the United States Eclipse Expedition. The spectrograph was a four-inch grating of 14,438 lines per inch ruled on a parabolic surface, which was used without slit. Weather conditions were splendid. The photographs are remarkable for their splendid detail throughout their whole length from D_3 to 3,300. There are about five thousand measurable lines in this region. The dispersion of the grating is about the same as for the 'Bruce three' spectrograph of the Yerkes Observatory and the Mills spectrograph of the Lick Observatory, the distance from D_3 to H being seven inches.

On the Minimum Number of Operators whose Orders exceed Two in any Finite Group: Dr. G. A. MILLER, University of Illinois, Urbana, Ill.

When just half of the operators of a group are of order 2 the order of the group is twice an odd number, and all the operators of odd order together with the identity constitute an abelian subgroup whose order is half the order of the group. Professor Miller's paper has for its main object the proof of the following theorems: If the order (g) of a group is written in the form

$$2^{a_0}p_1^{a_1}p_2^{a_2}\cdots p\lambda^{a\lambda},$$

p_1, p_2, . . ., $p\lambda$ being distinct odd prime numbers and $a_0 > 0$, the number of the operators whose orders exceed 2 can not be less than

$$\frac{(p_1^{a_1}p_2^{a_2}\cdots p_\lambda^{a_\lambda}-1)g}{2p_1^{a_1}p_2^{a_2}\cdots p_\lambda^{a_\lambda}}.$$

Moreover, it is possible to construct a group in which the number of operators whose orders exceed 2 is exactly equal to this number. If a group of order g contains the smallest possible number of operators whose orders exceed 2, the sub-group which is composed of all its operators which are commutative with one of the non-invariant operators of order 2 contains no operator whose order exceeds 2. This sub-group is a Sylow sub-group and just half of the remaining operators are of order 2.

Results of Physical Observations on the Saturnian System with the 18-inch Clark Refractor: Professor DAVID TODD, Amherst College, Amherst, Mass. (Presented by title.)

With the exception of those papers which appear upon the joint program of Friday morning, as given above, the papers of Section A were presented in connection with the program either of the Mathematical or of the Astronomical Society, according to the subject matter treated in each case. This arrangement was made in accordance with a resolution adopted at the Ithaca meeting to the effect that 'the sectional committee be empowered to turn over technical papers to the technical societies.'

LAENAS GIFFORD WELD,
Secretary

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA

II

A New Form of Meridian Mark: G. W. HOUGH.

Two years ago I established a meridian mark in order to study the change of azi-

muth for the $6\frac{3}{8}$-inch Repsold meridian circle. Collimator marks, according to published statistics, as well as from theory, do not seem to be sufficiently stable for the study of azimuth changes unless supplemented by frequent observations of circumpolar stars. The method I have employed for bringing a mark in focus is simple, direct and vastly preferable to the use of a long focus lens; since the marks may be located at such distance that any probable change in the place of the pin will not sensibly change the direction.

In photographic work, when it is desired to bring objects lying in different planes to a common focus the aperture of the lens is reduced. Accordingly, I made some experiments and found when the aperture of the object-glass of the Repsold meridian circle, of 6-foot focus, was reduced to one inch, all objects at about 1,000 feet and beyond were brought in good focus.

A concrete pier 2 feet square and rising $2\frac{1}{2}$ feet above the surface of the ground was erected at a distance of 1,140 feet. On the top of the pier was bolted a cast-iron box, 15 inches wide, 10 inches high and 10 inches deep. Inside the box is an adjustable brass plate with a hole 0.15 in diameter, behind which is placed a 50-volt 16-candle lamp. Electricity is supplied from a storage battery, at the observatory, which had been installed for rotating the dome and illuminating the instruments. During daylight, when the sun is not shining, the mark appears like a sixth-magnitude star; at night brighter.

In order that an object at a finite distance may suffer no change of direction, the hole in the cap which covers the object-glass must be in the optical axis. Any deviation will cause a displacement proportional to the focal length of the telescope divided by the distance of the object. At 1,000 feet one inch subtends an angle of 17″.1. Hence very great precision in the fit of the brass cap is unnecessary. In order to know whether the hole in the cap is in the optical axis, the cap may be revolved 180 degrees, or the mark may be observed with the *full* aperture of the object-glass. In the latter case there is seen a well-defined disk of light about 90″ in diameter.

In 1861 and for a number of years following, at the Dudley Observatory, I had a mark at the distance of six miles. After a rain the mark could be observed with great precision. The unsteadiness of a terrestrial mark does not depend directly on the distance.

The Significance of the Star Ratio: GEORGE C. COMSTOCK.

The number of visible stars increases very rapidly as we extend the count to fainter and fainter magnitudes, and any rational attempt at their enumeration must involve a limit, or limits, of brightness at which that enumeration shall cease. The rate of increase in the number of stars as this limit is made to move down the scale of magnitudes is called the star ratio, and the numerical value of this ratio in different parts of the sky and at different points in the scale of stellar magnitudes has been made the subject of research by many astronomers. From these investigations it appears that in general the number of stars is increased more than threefold and considerably less than fourfold for each increase of one magnitude in the limit to which the enumeration is extended. The ratio appears to be a little greater in the Milky Way than in extra-galactic regions and possibly a little greater for the brighter magnitudes than for the fainter ones, although it seems probable that the last relation is confined to the region outside the galaxy.

The point of major interest in the discussion is, however, that in general the rate

of increase is decidedly less than fourfold, while a very simple analysis shows that if the stars are strewn with some rough uniformity of distribution throughout a region of indefinite extent, the average star ratio should be very approximately a fourfold increase per magnitude. The disparity between this theoretical ratio and that found actually to obtain, throws discredit upon the hypothesis above made with respect to the distribution of the stars, and there has been reared upon it the current concept which represents the stellar system as of finite and measurable extent, broader in the galaxy because here the star ratio is relatively large, smaller at right angles to the Milky Way because here the star ratio diminishes. The idea is that the faint stars are faint because of their greater distance and are more numerous because the volume of space in which they may be distributed increases with the cube of the distance. But if the stellar system reaches out only to a certain limit and the space beyond is void, it can contribute nothing to the number of stars and the star ratio, while everywhere below the value that would obtain for an infinite system ought to diminish very rapidly as we approach the confines and deal with stars fainter than any that have been hitherto enumerated, although Professor Pickering holds that even within the range of magnitudes covered by his investigations, such a diminution in the value of the ratio is distinctly shown.

The present paper controverts the views above outlined and shows that the supposed fourfold ratio that constitutes their theoretical basis has been erroneously derived through ignoring an essential factor of the problem. The faint stars appear faint not only because of their greater distance, but because they actually emit less light than do the brighter ones, and because of this inferior luminosity they are nearer than has been assumed. This diminished distance is shown by observation of their proper motions and because of it we have a diminished space available for the faint stars, they are less numerous and the star ratio smaller than is required by the erroneous theory above considered. When the diminishing intrinsic brightness of the fainter stars is properly taken into account the author finds from a discussion of the star ratio for galactic stars down to the faintest yet enumerated (the Herschel gauges), that there is here no indication of a limit to the stellar system.

Outside the galaxy the conditions are different, the values of the star ratio are progressively smaller and suggest some one of the following alternative conditions or possibly a combination of them:

(*a*) At right angles to the galaxy the limits of the stellar system fall within the range of vision, as indicated above.

(*b*) The stars remote from the plane of the galaxy are on the average progressively less luminous than those in the galaxy.

(*c*) The transmission of light through the extra-galactic spaces is impeded by some absorbing medium which serves to diminish the brilliancy of the stars in larger measure than is the case in the galaxy.

Any of these alternatives will serve in explanation of the observed facts and it is not now feasible to make definitive choice among them.

Preliminary Wave-lengths from Flash Spectra taken in Spain, 1905: S. A. MITCHELL.

The flash spectra were photographed by means of a Rowland four-inch grating ruled on a parabolic surface. The grating was used without a slit, so that the spectrograph consisted merely of grating and photographic plate. The spectra, which show wonderfully fine definition, extend

from the *D* lines to λ 3,300 in the violet, a distance of 9.5 inches.

Measurements are now being made on the three or four thousand lines of the flash spectra. These photographs show a dispersion about the same as the Bruce three-prism spectrograph of the Yerkes Observatory and the Mills spectrograph of the Lick Observatory, or a dispersion one fifth that of a twenty-one-foot grating of ordinary Rowland mounting in the first order spectrum, or one tenth of the second order. The eclipse spectra were practically normal. Wave-lengths thus far deduced show a probable error less than five-hundredths of an Ångstrom-unit.

Comparison of Results of Observations with the Reflex Zenith Tube and Zenith Telescope at the Flower Observatory during 1905 and 1906: C. L. DOOLITTLE.

The Temperature of Mars: PERCIVAL LOWELL.

On the Absence of Long Heat Waves in the Sun's Spectrum: E. F. NICHOLS.

Formulas for the Comparison of Astronomical Photographs: HAROLD JACOBY.

This paper contains formulas suitable for the direct comparison of rectangular coordinates measured on different astronomical negatives. The problem here involved supplements what may be called the fundamental transformations in the reduction of celestial photographs; *viz.*, the calculation of right-ascensions and declinations from rectangular coordinates, and rectangular coordinates from right-ascensions and declinations.

Light Curves of New Variable Stars of the Algol Type, and of Short Period: HENRIETTA S. LEAVITT.

In a recent circular of the Harvard Observatory thirty-six new variable stars were announced, mostly brighter than 9.5 at maximum. All are within fifteen degrees of R. A. 12^h, Dec. — 60°, the region including both the Southern Cross and the Nebula in Carina. About sixty new variables in this area, mostly fainter than the tenth magnitude at maximum, had been announced in previous circulars. A large proportion of the new objects appear to have short periods, and several are of the Algol type. These are now being studied with a view to determining their periods and light curves. The periods of four have already been announced, those of three others are now made public for the first time. All but one of the seven variables are of the Algol type. The periods vary from nine tenths of a day, to five and one third days, while the smallest and the largest ranges observed are four tenths of a magnitude, and two and one half magnitudes, respectively.

The variable C. P. D.—50° 3,809 is of special interest, as the period is equally divided by a secondary minimum. The principal minimum is nine tenths of a magnitude fainter than the normal brightness, 9.3, while the secondary minimum is four tenths of a magnitude fainter than the normal. The average deviation from the light curve of a single observation is very large, being no less than ± 0.14 magn., while the average deviation for all the other Algol variables here described, is only ± 0.07 magn. This large deviation does not appear to be due to accidental errors of observation, though the variable was difficult to measure on many of the plates. It has not been found possible to improve the period on the supposition that it is constant, and it is probably to be corrected by a third term, not yet determined.

C. P. D.—49° 6,972 has a large range. The faintest magnitude observed is 11.5, which is two and a half magnitudes fainter than the normal brightness; but no observation at minimum has as yet been secured,

and the form of the light curve at that point is not determined.

C. P. D.—63° 2,485 was at first supposed to be of the Algol type, but has been found instead to be a short-period variable of unusual interest. As has already been announced in a recent circular, the light curve resembles that of an Algol variable with a minimum covering about half the period, but the light appears to be changing continuously, though very slightly, even when near maximum. As the range is only four tenths of a magnitude, four independent observations were made on each plate. By taking means, the accidental errors were reduced one half. The mean magnitudes were then arranged in the order of phase, and the mean phase and magnitude was taken for each successive group of five plates. The average deviation from the light curve of the points thus obtained is only ± 0.02 magn., and may be compared with the deviations found with the best photometric measures.

The large proportion of Algol variables among those discovered in this region is interesting. Of thirty-six variables announced last month, four have already been shown to be of the Algol type, and others, of which the observations have not yet been discussed, are supposed to belong to the same class. On the other hand, of more than seventy variables in Scorpius and Ophiuchus, announced two years ago, few, if any, appear to vary in this manner. The same is true of the Magellanic Clouds. The present study of the distribution of variable stars is in a very early stage and much generalization from the results as yet obtained is rash. Yet it has already become evident that certain kinds of variables are apt to be found in groups. It is desirable that the number of persons engaged in this research should be increased, so that the systematic survey of the heavens may be completed with a reasonable degree of thoroughness during the next few years. Evidently it is of the highest importance to ascertain the types to which new variables belong, even if their number is too large to permit the computation of all the periods.

A Peculiar Binary System: Eric Doolittle.

Latitude Terms of Long Period, from the Flower Observations: C. L. Doolittle.

This series embraces a period of seven years and nearly two months, and is practically homogeneous in all respects. As a term having a period of about six years has been supposed to be indicated by similar series elsewhere, it seems desirable to examine my results for evidence on this point.

Without making any assumption as to the law of latitude variation, the intervals from minimum to minimum were found graphically. The maxima were not employed for this purpose, as they were less clearly indicated. Six periods were found as follows:

1st	459 days
2d	410
3d	470
4th	439
5th	446
6th	416
Mean	440 days

5 periods = 2,200 days
6 Julian years = 2,191.5 days

The difference 8.5 days is of no importance for present purposes.

This close agreement seems to fall in line with the possible existence of a term having a period of about six years.

The method of procedure was as follows: For each interval from minimum to minimum, terms of the form $x \sin \theta + y \cos \theta$ were removed from the given values of the latitude. A series of 103 equations was then obtained of the following form:

$$\Delta + ax + \sin\theta \cdot y + \cos\theta \cdot z + \sin 2\theta \cdot u + \cos 2\theta \cdot v = n.$$

Δ is a constant correction to the latitude assumed.

x a uniformly progressive change.

The period of θ is six years.

The solution results in the following expression for $\Delta\phi$ in units of the second decimal place:

$$-1.96 \sin\theta + 0.35 \cos\theta + 1.25 \sin 2\theta + 0.94 \cos 2\theta,$$

x is quite inappreciable.

The maximum and minimum values of this expression are as follows:

Maximum	1898, February 1,	+ 0″.024
Minimum	1902, April 9,	− 0″.035

The range, 0″.059, seems too great to be altogether fictitious when the amount and character of the data employed are considered.

Period of the Solar Rotation: PHILIP FOX.

An investigation of the solar-rotation period based upon measurements of positions of 1,600 calcium flocculi on one hundred of the Rumford spectroheliograms taken at the Yerkes Observatory in the year 1904, gives the following results:

ϕ		ξ	P
0°	to 5°	14.50°	24.82d
5	10	14.44	24.93
10	15	14.18	25.38
15	20	13.92	25.86
20	25	13.68	26.32
25	30	13.95	25.80
30	35	13.68	26.31
35	40	13.25	27.18

The investigation will be continued, using the plates for the years 1905 and 1906.

Opportunities for Solar Research: GEORGE E. HALE.

It is safe to say that every astronomer would prize an opportunity to observe any of the fixed stars from a position where its disk would appear as large as the sun. It does not seem probable, however, that such observations of stellar phenomena can ever be made, except in the case of the sun itself. For it should ever be borne in mind, when considering the importance of solar research, that our most intimate knowledge of stellar phenomena must be derived from solar observations. In the case of the other stars, we may determine their positions, measure their radial velocities, observe their brightness and analyze their light, but we have no means of studying the details of their structure, which must be understood before we can advance far in the solution of the great problem of stellar development. Thus we are driven back to the sun and forced to the conclusion that this typical star well deserves our most serious attention, and the application of every available means of research.

One can not but be impressed, when considering the sun from this standpoint, with the comparative neglect of the numerous opportunities awaiting the student of solar physics. It is possible, by the application of easily available instruments, for any careful student, wherever situated, to solve solar problems of great importance. If time permitted, it could be shown that almost all the apparatus required in such work can be constructed at very small expense. For our present purpose, however, let us assume that the observer has at his disposal one of the cœlostats so commonly employed in eclipse work. If this cœlostat has a rather thick mirror, which is frequently resilvered, it may be depended upon to serve well for solar work, provided that the mirror is shielded from sunlight during the intervals between the exposures of photographs, and that these exposures are made as short as possible. We may assume that the sunlight is reflected from the cœlostat mirror to a second plane mirror (which should also be as thick as possible) and from this mirror to an objective, which should have an aperture of at least

6 inches and a focal length of from 40 to 60 feet. In place of this objective, a concave mirror, of similar aperture and focal length, may be employed. This apparatus will furnish the necessary means of forming a fixed solar image, of large diameter, within a laboratory, where accessory apparatus can be mounted. Let us now consider briefly some of the investigations that can be undertaken.

Direct Photography.—The routine photographic work, done under the direction of the Greenwich Observatory, provides ample material for the study of the positions and motions of sun-spots, but special investigations may well be undertaken with the aid of direct photographs. The important thing in all solar work is not merely to make observations of some single phenomenon, but to carry on two or three series of carefully correlated observations, so designed as to throw light on one another. For example, Mr. Maunder has recently found that the rotation periods of sun-spots in nearly the same latitude show differences as great as those encountered in passing from the equator to the highest latitude in which the spots are found. The cause of such differences may well be a subject of most careful investigation. The proper motions of spots, which are associated with their period of development, must be fully taken into account. We might also make the hypothesis, merely for the purpose of testing the question, that the rotation period of a sun-spot depends upon its level with respect to the photosphere. For this reason it would be desirable to investigate, in connection with the study of the rotation, the question of the level of sun-spots. A simple means of doing this will be mentioned later. But it may be added here that the question of level raises other considerations, which should not be left out of account. It is probably worth while to investigate photographically the old Wilsonian hypothesis, since visual observations have proved so discordant in attempts to determine the relative widths of the preceding and following penumbra of spots at various distances from the center of the sun. As a sun-spot is depressed below the level of the surrounding faculæ, the vexed question of the visibility of the umbra near the limb may depend upon whether faculæ are present or missing on the sides lying in the line of sight. It is quite possible that the temperature of the umbra may vary with its distance above the photosphere. Thus correlation between observations bearing on spot level and observations of spot spectra is desirable.

Spectroscopy.—The spectroscopic study of solar phenomena has been greatly retarded, through delay in adoping suitable instruments. The short-focus spectroscopes attached to equatorial telescopes are admirably adapted for visual observations, but in photography their linear dispersion is much too small to realize the full resolving power of the grating employed. In laboratory work, on the contrary, while the spectroscopes have been sufficiently powerful, they have usually been of the concave grating type, where astigmatism interferes seriously with the study of solar details, and the solar image on the slit of the spectroscope has been so small that the individual phenomena, in any event, could not be separately distinguished.

The construction of a powerful spectrograph of the Littrow type is an extremely simple matter. A small slit, mounted on a short metallic tube, is supported immediately above a long narrow photographic plate. The wooden support for plate-holder and slit rests on a pier and forms the end of a long light tube of rectangular section, which is closed at its other end by

the wooden support for the lens, which serves at once for collimator and camera. The angular aperture of this lens is, of course, defined by that of the objective which forms the solar image on the slit, but if possible its focal length should be from ten to twenty feet. The rays, after being rendered parallel by the lens, fall upon a grating, which need not be larger than a four-inch (a much smaller one would do very useful work). The spectra should be photographed in the second, third or fourth order, so as to give sufficient scale.

With such an instrument, new work of great value may be done. Even with a very small solar image, a photographic study of the solar rotation should yield results of great precision. Halm believes, from his spectroscopic work, that the rotation period varies with the solar activity. This is yet to be confirmed, but the question well deserves investigation. There is some reason to think that the rotation period is not the same for different substances in the reversing layer. The iron lines, for example, may give values different from those obtained with the carbon lines. It is also interesting to inquire whether the enhanced lines of an element give the same period as the other lines in its spectrum.

Another interesting investigation, which does not require a large solar image, is the study of the radial velocity of the calcium vapor in the flocculi. It is only necessary to measure, with great precision, the wavelengths of the H_2 and H_3 lines, corresponding to various points on the solar image. In this way the rise and fall of the calcium vapor in the flocculi can be ascertained. To be of the most service, this investigation should be carried on in conjunction with some other study of the flocculi.

The photographic study of sun-spot spectra offers a most promising opportunity. It is a very easy matter to photograph spot spectra in such a way as to record for study thousands of lines which are beyond the reach of visual observation. Nevertheless, this has been accomplished only recently, simply because spectrographs of suitable design have not previously been applied in this work. At the Solar Observatory on Mt. Wilson it has been found that, in general, the lines strengthened in spot spectra are strengthened in the laboratory when the temperature of the vapor is reduced, while the lines that are weakened in sun-spots are weakened in the laboratory under the same conditions. Thus it appears probable that the temperature of the spot vapors is below that of the reversing layer. This conclusion has been confirmed by the discovery in the spot spectrum of the flutings of titanium oxide. This compound thus exists at the lower temperature of the sun-spot, but is broken up into titanium and oxygen at the higher temperature of the reversing layer. The bearing of this result upon stellar spectroscopy will be seen when it is remembered that the flutings of titanium oxide form the principal feature of the spectrum of the third-type stars. It has also been found that Arcturus gives a spectrum resembling very closely the spectrum of a sun-spot. A further study of this question will require a large number of observations of spot spectra, with special reference to the question of variations in temperature, as indicated by variations in the relative intensity of the spot lines. As already remarked, the temperature of spots may also depend upon their level, and this possibility must be borne in mind.

Work with the Spectroheliograph.—It is perhaps commonly supposed that the spectroheliograph is necessarily an expensive instrument, out of reach of the average

observer. As a matter of fact, however, a spectroheliograph capable of giving the best results can easily be constructed of materials ordinarily available in any observatory or physical laboratory. It is sufficient, for many purposes, to photograph only a narrow zone of the solar image. In this case small lenses will suffice for the collimator and camera, and small prisms for the optical train. The lenses and prisms may be mounted in wooden supports, on a wooden platform, rolling on four steel balls in V-shaped tracks. The motion of the instrument across the solar image may easily be produced by a simple screw, driven by a small electric motor. Such a spectroheliograph was used to good purpose at the Solar Observatory before the permanent instrument was completed.

Brief mention may be made of some of the numerous investigations possible with such an instrument. It has recently been found at the Solar Observatory that the dark hydrogen flocculi, photographed near the sun's limb, are slightly displaced with reference to the corresponding calcium flocculi. In general, they lie nearer the limb. This probably indicates that the absorbing hydrogen clouds are, on the average, at a higher level than the brilliant calcium clouds. This subject deserves careful investigation, extending over a considerable portion of time. The type of spectroheliograph just referred to is as suitable for the purpose as any instrument that can be constructed. Another question, which seems to be somewhat more difficult to solve, is the actual difference in elevation of the calcium flocculi, as photographed in the H_1 and H_2 lines. Indeed, it is still a question as to how important a part the dense calcium vapor plays in determining the form of the H_1 flocculi. These objects resemble the faculæ so closely that they appear practically identical with them, though slight differences, which are apparently genuine, are occasionally found.

Another method of investigating this whole question of levels is afforded by the spectroheliograph. It will be remembered that when the level of sun-spots was last under discussion, reference was made to the relative radiation of the umbra and neighboring photosphere, corresponding to different distances from the center of the sun. It was pointed out that when a spot approaches the limb, its radiation decreases less rapidly than that of the photosphere. The natural conclusion was that the spot lies at a higher level than the photosphere and thereby escapes much of the absorption produced by a comparatively thin layer of absorbing matter. Recent observations at Mt. Wilson have shown, however, that the proportion of violet light in sun-spots is much smaller than in the case of the photosphere. As it is known that the violet rays undergo much more absorption near the sun's limb than those of greater wavelength, it is obvious that the light of the spot would suffer less absorption, even if it were at the same level as the photosphere. Thus the only proper method of investigating this question will be through the use of monochromatic light.

The spectroheliograph affords a simple means of accomplishing this. It is only necessary to make photographs of the spot and adjoining photosphere, corresponding to various distances from the sun's center. The camera slit should be set on the continuous spectrum (not on a line), preferably in the violet or ultra-violet, since the change of absorption would be most felt in this region. In order to make photographic comparisons easily possible, the intensity of the photosphere should be reduced to approximately the intensity of the umbra, by means of a dark glass, mounted over the collimator slit, but not

covering that part of the slit through which the light of the umbra passes. It is obvious that a large image of the sun will be required in this work.

The spectroheliograph can be applied to other studies of absorption. The H_1 flocculi, for example, are reduced in brightness near the sun's limb much more than the H_2 flocculi, presumably because the latter lie at a higher level. These differences can be studied photometrically on spectroheliograph plates made for the purpose. Since it is a question just what level is represented by the background (between the flocculi) in calcium, hydrogen or iron photographs, the instrument should be arranged so as to permit photometric comparisons with the light of the photosphere, of practically the same wave-length as the calcium, hydrogen or iron line employed.

These new applications of the spectroheliograph have only recently occurred to me, and are mentioned because of their suitability for use with instruments containing prisms of ordinary height, capable of photographing only narrow zones of the solar image. Numerous other problems might be mentioned, such as the comparative study of H_1, H_2 and H_3 photographs, and of calcium, hydrogen, and iron images; the distribution of the flocculi in latitude and longitude, their varying area, as bearing on the solar activity and on terrestrial phenomena, and their motion in longitude, as measuring the solar rotation. But limitations of time forbid more than a mere reference to work and methods, the details of which are discussed elsewhere. My purpose has been accomplished if I have shown that with comparatively simple instrumental means any careful observer may secure important results. In much of this work it is desirable that investigators occupied with similar problems should cooperate with one another. The International Union for Cooperation in Solar Research was organized with this end in view. It has already inaugurated solar studies, on a common plan, in several different fields, and is preparing to extend the range of its activities in the near future.

Harold Jacoby,
For the Council

SCIENTIFIC BOOKS

Rock Minerals, their Chemical and Physical Characters and their Determination in Thin Sections: Joseph P. Iddings. Wiley and Sons, New York. Pp. xii + 548, with numerous figures in text.

In presenting this work the author and publishers have won the gratitude of every American student in petrography, and of every teacher as well. Heretofore, the only systematic and comprehensive treatises available have been the 'Mikroskopische Physiographie' of Professor Rosenbusch or Professor Iddings's condensed translation of the same, and the works of Fouque and Levy. While no one would for a moment wish to disparage the work of one who has fairly earned the title of father of modern petrography, yet, as may readily be comprehended, the manner of presentation in the first-named publication, as well as the language in which it is presented, is German, and not always easy of comprehension to the average American student.

There have been, it is true, other works on the subject, in English, as Professor Luquers's 'Minerals in Thin Sections' and Harker's 'Petrology for Students,' but such make no pretense at completeness, and it has remained for Professor Iddings to give us a book as comprehensive and systematic as those of the German and French writers noted.

Within the limits of some 550 pages Professor Iddings includes not merely a description of the optical properties and methods of determination of all the ordinary rock-forming minerals, but also chapters on their chemical and physical characters. The critical chapter of the book is undoubtedly that relating to the optical properties of minerals, and it is apparently in recognition of this that the author has devoted upwards of 100 pages

to a discussion of the theory of light, its reflection, refraction and polarization, the manner in which it is acted upon by isotropic, uniaxial and biaxial crystals, and finally how these properties may be made of determinative value by means of a properly constructed microscope, the various appliances and method of application of which are fully explained. Pages 201–526, inclusive, are devoted to detailed discussions of the characteristics of the individual species of the rock minerals. Here the author is at his best, and has left little to be desired in the way of clear and exhaustive treatment. Each mineral is considered with regard to its chemical composition, alteration, crystal form, optical properties, color, inclusions, mode of occurrence, resemblances and laboratory reproduction, in the order here given. The arrangement of the minerals, on a chemical basis, strikes one, however, as a trifle illogical, since the methods of determination are almost wholly optical and one who has worked with the book of Rosenbusch will at first find it awkward. Pages 527–541 are devoted to tables giving these optical characters. The book is illustrated by upwards of four hundred figures—mostly crystal outlines—in the text. Many will miss the plates of micrographs of thin sections found in the work of Rosenbusch, but it is possible that Professor Iddings, as a teacher, wished to guard the student against the danger of relying too much upon the appearance of a mineral rather than upon its optical properties. The adoption of a new system of numbering with each change of subject, though the same as that used by Dana in his system of mineralogy, is a little confusing to one turning the leaves at random, but inasmuch as each figure occurs on the page of text in which reference to it is made, no serious confusion is likely to arise.

The book is of good size and form for convenient use, well printed and bound, and that it is essential to every student and teacher must be self-evident. George P. Merrill

The Human Mechanism, its Physiology and Hygiene, and the Sanitation of its Surroundings. By Hough and Sedgwick. Boston, Ginn & Company.

This book adds another to a series of very useful text-books on the subject of physiology designed for secondary schools. It is, however, rather unique among the series in several respects, the more distinctive of which the present review will endeavor to point out.

First among them is the point of view from which the authors approach the subject, namely, as implied in the title, The *human body* as a *mechanism*. This conception the authors regard as "not only the sure foundation of physiology, hygiene and sanitation, but is also surprisingly helpful in the solution of many questions concerned with intellectual and moral behavior."

A second feature upon which emphasis is placed is the conception of the mechanism *as a whole*. "Avoiding that form of physiology which looks chiefly at the organs and overlooks the organism, we have constantly kept in view the body as a whole, in order that physiology may become the interpreter of the common physical phenomena of the daily life and find in hygiene and sanitation its natural application in conduct." In this view there will doubtless be general concurrence.

Still a third feature, more or less distinctive, is the large consideration given to problems of *sanitation,* both domestic and public. So far as the reviewer is aware, this is the only text-book designed for schools in which this aspect of physiology has received the degree of attention it deserves. Just how far this may properly come within the scope of the average school course will doubtless be a matter of divided opinion; as may likewise be the further query as to how far details of sanitary principles come within the intelligent apprehension of the average pupil of the grades likely to be affected. But allowing for such debatable differences, it would seem that provision should be made for some insight into this increasingly important subject. To the vast majority of pupils of the high school this will be about the only opportunity for such insight, and it is the reviewer's conviction that the authors have done well to put it well to the front in their book.

There is another point, however, mainly a pedagogical one, which seems open to some

criticism, namely, whether in the vast body of admirable and trustworthy information, which makes the book a veritable cyclopedia, the essentially didactic and disciplinary aspects of the subject have not suffered an undesirable and unnecessary eclipse. If the primary aims of physiology in the schools be informational, and the importance of this will not be questioned, then some subordination of those methods of observation and experiment so distinctive of science may in measure be justified. But even in that case it may well be questioned whether these very methods do not afford a *distinctive type* of information, more vital and impressive, and at the same time incomparably more abiding; and this the reviewer believes to be the case. It is much to be regretted, therefore, that at least some provision had not been made in the body of the text and throughout for pertinent experiment and demonstration. The almost total absence of anything savoring of laboratory directions is hardly atoned for in the brief prefatory statement that varying facilities in different schools made this less imperative. The very presence of such directions would have served to promote a larger and more uniform system of judicious laboratory practise.

Upon the whole, the book is easily among the very best now available, and indeed far and away superior to the average text-book of similar scope. It marks a decided step in advance, and will doubtless find a wide and growing field of usefulness, both in the upper years of the high school and beginning courses in college.

In its typography and other mechanical aspects the book seems exceptionally free from glaring defects, and maintains the high repute of the publishers in this line of book-making.

C. W. H.

SCIENTIFIC JOURNALS AND ARTICLES

The American Naturalist for March contains but three papers, though these are of considerable length. The first, 'Studies on the *Ophioglossaceæ*,' by D. H. Campbell, deals mainly with the morphology of the peculiar, fertile leaf segment, or sporophyll. R. W. Shufeldt discusses 'Polygamy and Other Modes of Mating among Birds,' the object being avowedly to throw some light on the question of mating among mankind. A large number of statements are made, the bearing of which is to be given in another paper. Outram Bangs writes 'On the Wood Rails, Genus Aramides, occurring North of Panama,' describing as new one form from Mexico to which the name *Aramides albiventris mexicanus* is given.

The American Museum Journal for March has illustrated articles on the mounting of 'The African Lion Hannibal,' 'The Naosaurus, or Ship-Lizard,' and 'A New Eskimo Exhibit,' and contains the lecture schedule for the month. The mounted lion, and the bizarre skeleton of Naosaurus are respectively triumphs of the taxidermist and preparator of fossils.

The Museums Journal of Great Britain for February has various articles on museum cases; the first, by H. Bantry White on 'Some Improvements in Museum Cases,' describes methods of making iron cases by which their cost has been greatly reduced. F. A. Lucas gives briefly his ideas relative to 'The Structure and Arrangement of Museum Cases,' finding a lack of effect in iron cases and emphatically endorsing the bay system of arrangement. 'The Liverpool Museum Extension' deals with the rearrangement of the zoological and anthropological collections in a consecutive, educational plan. The view of the zoological hall impresses one with the idea that it is a little too narrow for the best results.

THE Springfield Museum of Natural History has issued a 'leaflet' entitled 'Bird Migration,' giving the dates of arrival of one hundred species of birds found within ten miles of Springfield, during the springs of 1901 to 1906, with spaces reserved up to 1910. The list is arranged chronologically for 1901, although there is considerable variation in the dates of arrival of the species subsequently.

The Bulletin of the Charleston Museum for March is mainly devoted to an excellent article by Mrs. Paul M. Rea on 'The Relation of the Museum to the Schools.'

The Science and Art Museum Dublin is issuing a series of 'guides' to the collections, which are sold at the nominal price of a penny. The last two of the series, devoted to armor, and to arms (European) are by M. S. D. Westropp and comprise a descriptive catalogue of the specimens in the museum, with a large amount of general information as to the classes of objects described. They are extremely interesting and models of their kind.

SOCIETIES AND ACADEMIES

THE GEOLOGICAL SOCIETY OF WASHINGTON

At the 187th meeting of the society, on February 13, 1907, Mr. J. S. Diller presented briefly the results of extended studies by him on the age of the auriferous gravels in Oregon and the discovery of marine Eocene fossils in the same.

Mr. Fred. E. Wright exhibited artificial crystals of cuprite and an asbestos-like mineral of the composition of tremolite, both formed at high temperatures and under considerable pressure.

Regular Program

Mr. Whitman Cross gave a brief review of the recent article on 'New Textual Terms for Igneous Rocks' by Cross, Iddings, Pirsson and Washington in the *Journal of Geology*, XIV., 692–707, and emphasized the underlying principles which guided the authors in their classification and description of the textures of igneous rocks.

The Pine Mountain Fault: Mr. R. W. Stone.

Pine Mountain forms part of the boundary between Kentucky and Virginia and is a long narrow ridge having a general elevation of 3,000 feet. This discussion deals only with the northern end of the mountain from Pound Gap to Big Sandy River. The Virginia side of the mountain is comparatively steep, the strata dipping southeast at angles up to 25 degrees, while the north or Kentucky side is precipitous and a good example of a fault scarp. The great fault which formed the mountain is on the north side and parallels the crest of the ridge for many miles. In the 'breaks' where Russell Fork of Big Sandy River passes the end of the mountain in a gorge 1,000 feet deep, a diagrammatic section shows clearly the uplifting and over-riding of the Lee conglomerate on the upturned edges of the Coal Measures. In the coal field immediately west of the Pine Mountain the Lower Elkhorn seam commonly shows a fifteen-inch bench of laminated coal. It has every appearance of squeezing and movement, the coal being crushed to a flaky condition and the surfaces of the flakes slickensided. The lamination may be parallel to the bedding, but is often tilted or contorted; it decreases and disappears at a distance of several miles from the mountain.

Phosphate Deposits in the Western United States: Mr. F. B. Weeks and Mr. W. F. Ferrier.

It has been found during the past few years that the limestone strata of the upper Carboniferous of the Central Cordilleran region include a series of oolitic beds containing a variable percentage of P_2O_5 and varying in thickness from a mere trace to ninety feet. These beds are known to occur in Idaho, Wyoming, Utah and Nevada, and future exploration may show that they have a still wider distribution. They are usually underlain by blue-gray compact limestone strata which in turn pass into sandy limestones and yellow sandstones. The phosphate series consists of alternating layers of black phosphatic material, shale and hard blue or brown compact limestone which is often fossiliferous with *Rhynchonella, Chonetes* and *Euomphalatrochus* as characteristic forms. Within the series the phosphate beds vary in thickness from a few inches to ten feet, some of which are almost entirely oolitic in character and commercially valuable because of their high content of P_2O_5, the average analysis of carload lots giving 32 per cent. P_2O_5 equivalent to 70 per cent. bone phosphate.

In Utah the phosphate series is exposed in Weber Canyon near Croydon and also near Woodruff; in Wyoming, near Sage and also near Cokeville, where it extends along the west face of the Sublette Range on the east side of the valley of Thomas Fork; on the east side of Bear Lane and along the west

face of the Preuss Range in Idaho, at Montpelier, Bennington, Georgetown and in the vicinity of Swan Lakes. This discovery has opened a new industry in the west; its future development is dependent on the cost of transportation to foreign and domestic markets.

THE 188th meeting of the society was held on February 27 and was devoted to a consideration of the 'Methods of Igneous Intrusion.'

The discussion was opened by Mr. Whitman Cross, who directed it to the methods by which the large igneous masses, such as laccoliths, stocks and batholiths, have come to the places where they are now visible. The three main agencies called upon in current literature to account for these masses are: (1) Mechanical displacement of the invaded rocks, (2) fusion and assimilation of the rock by the magma, (3) 'magmatic stoping.'

It was claimed that laccoliths, in the sense of Gilbert's original definition, and many closely allied bodies, are beyond question produced by a purely mechanical uplift of rocks, usually sedimentary, above the plane of intrusion; that assimilation and stoping are at the most rare and subsidiary phenomena. No instances are known to the speaker.

The origin of stocks and batholiths, viewed as very similar except in point of size, is less evident than that of laccoliths, because we can ascertain the relations for only a portion of each mass. That fusion of country rock by an invading magma, with subsequent assimilation, is a demonstrated or adequate explanation for stocks and batholiths was denied. This hypothesis is usually advanced with naïve disregard for the difficulties involved in its acceptance. Among these were mentioned: (1) The manifest impossibility of assimilating and assimilated rocks occupying the same space: (2) the physical problem of supplying and maintaining the heat necessary to keep the magma liquid in spite of conduction into wall rock and absorption in the fusion assumed; and (3) the necessity for demonstrating that an invading magma, as, for instance, one of granitic composition, had been changed in character through assimilation of quartzite, limestone, or basic igneous rocks. In most stocks and batholiths there is absolutely no evidence that fusion of wall rock has occurred. It can scarcely have taken place on a large scale without leaving evidence of such action. While fusion must surely be assumed as taking place under certain conditions, there is no good reason to believe that those conditions were realized in known stocks and batholiths. Even should extensive fusion be demonstrated for certain cases, that process is not in itself competent to explain the masses under discussion.

Mr. Cross called special attention to the hypothesis of 'magmatic stoping' advocated forcibly by Daly in the last few years. After assuming that crustal movements must result in liquefaction of rock locally through decrease of pressure, the magma is pictured by Daly as eating its way upward by a process in which the main factors are the detachment of blocks of rock from the cover of the molten mass, their descent into the lower and hotter parts of the magma and consequent fusion and absorption. It is supposed that the magma may thus quietly rise far into the crust to horizons which through erosion have in many cases become accessible to our observation.

The magmatic stoping hypothesis of Daly rests upon two fundamental assumptions—viz., that the magmas of stocks and batholiths possess a high degree of liquidity and that the specific gravity of most crystalline rocks is greater than that of even a gabbroic magma in the assumed liquid condition. The high liquidity of batholithic magmas, although assumed by Daly as a matter of common acceptance, was questioned by the speaker on the basis of recent physical investigations and observed facts. In general, the facts of field occurrence are believed to show that the magmas of batholiths have in reality a high sustaining and lifting power; that blocks of country rock do not sink, but rather float, in the magmas; that basic inclusions, often of considerable size, are brought up from the depths in batholithic magmas. The data at our disposal for estimating differences in density between magmas and solid rocks are

meager and inconclusive. In any case, the hypothesis fails to account for basic stocks in highly siliceous rocks.

Referring to stocks and batholiths which he had studied, Mr. Cross stated that they testified rather to violent and powerful ascensive forces back of the magmas and expressed the belief that in such masses, as in laccoliths, the coming to place of the magmas was in first degree a mechanical displacement of the invaded rock, as such.

Mr. G. F. Becker considered the intrusive magmas from a physical and chemical standpoint and emphasized his view that such magmas are emulsions rather than liquids; that, at the time of intrusion, they consist largely of crystal aggregates with a small amount of interstitial material not yet crystallized—a fact evident from the mutual interference and simultaneous crystallization of the components of any deep-seated rock. This state was compared to that of partially melted snow which consists of ice crystals with some free water; in short, the magma at the time of intrusion is a soft solid like modeling clay and the intrusion must therefore follow different laws from those of an intrusive fluid. In particular he pointed out that semi-solid magmas may support masses of relatively large density. The presence of aplites and pegmatites in granular intrusives and not in porphyries is significant in support of this theory of the soft solid condition of deep-seated intrusive magmas.

Mr. A. L. Day directed attention particularly to the physical conditions which must be reckoned with in formulating the stoping hypothesis.

1. The wall rocks in these cases must be accounted very good conductors of heat. It is, therefore, difficult to conceive of a sharp temperature difference between the intruding mass and the wall rock existing for more than a very short interval of time, whatever the relative masses involved. If the amount of heat to be distributed is large, active resorption must occur; if small, adjacent layers of the intruding mass will very soon become solid or hyperviscous.

2. The evidence which has been gathered by the Geophysical Laboratory points persistently to the extreme viscosity of all the highly siliceous minerals and mixtures, even at temperatures far above their melting points.

3. There is a very reasonable probability that most crystalline rocks are more dense at the melting temperatures than the liquids which they form, but it will be remembered that Professor Barus's experimental proof was confined to the gradual transition from liquid to amorphous glass, and therefore leaves the important question still open.

Mr. Andrew C. Lawson criticized Daly's hypothesis from the point of view of the great diameter of certain batholiths and the flatness of the arch roofing them. With a span of 100 miles or more, if the roof were specifically heavier than the invading magma, he did not see what would prevent its complete foundering. Referring to the high viscosity of the feldspars and quartz, as determined by Dr. Day's experiments, he indicated that, while this was a property of the individual crystals, it did not finally prove that mixtures of such materials in magmatic fusion with other constituents of granite would be so highly viscous. Dr. Becker had drawn the conclusion that porphyritic structures could only be developed in fluids of high molecular mobility. Now the granite rocks of the High Sierra were highly porphyritic over a wide extent. The large well-formed crystals of orthoclase, commonly over an inch in length, showed that in that great batholith the magma had not been highly viscous. Moreover, these porphyritic orthoclases were chiefly aggregated in the upper levels of the batholith as if they had been assembled there by flotation from the lower levels, again indicating absence of high viscosity. Further, the granite of the Sierran batholith swarms with angular inclusions. These are not fragments that had been torn from the roof and caught in process of sinking. They are mineralogically allied to the lamprophyres, and represent fragments derived from the shattering of deep-seated masses ascending with the upwelling of the batholithic magma. These facts all indicate fluidity. The speaker had, however, been one of the first to argue for the high viscosity of

granitic magmas in the *final* stages of their consolidation, such viscosity ensuing after the crystallization of the feldspars and due to the behavior of the residual free silica of the magma which crystallized as quartz. It was well known that while rhyolitic magmas were more viscous than basaltic lavas, they were nevertheless fluid enough to flow as expansive sheets; and many granitic batholiths approximated such rhyolites in their composition sufficiently to indicate that they were not, except in the final stages of solidification, so highly viscous as to be regarded as solids rather than fluids. The speaker was glad to hear Dr. Day minimize the influence of pressure. He recalled the case of vertical basic dykes which in horizontal section graded from very dense compact porphyritic rocks on their margins to coarse gabbroic rocks in their middle part, 50 feet or less distant. This gradation in structure and texture necessarily occurred under the same pressure, and proved that pressure exercised but little control upon the development of these features.

Mr. G. O. Smith cited observations on intrusion phenomena in Washington, Utah and Massachusetts. In the Tintic Mountains the intrusive monzonite includes angular fragments of quartzite and limestone which have been carried upward after detachment from the wall rock, showing absence of assimilation by the magma and of sinking of the fragments in the same.

Mr. F. E. Wright described briefly examples of batholithic intrusion of granites in southeast Alaska, and of local recrystallization and assimilation of invaded rocks, and emphasized the important rôle of magmatic solutions in producing such alterations, rather than direct melting and absorption by the magma and recrystallization of the whole on cooling.

Mr. Waldemar Lindgren cited a number of examples of intrusions of granitic and dioritic rocks in the Sierra Nevada from which it was clearly apparent that a very considerable pressure was exerted by the intruding magma on the surrounding, steeply dipping slates. In many cases the intrusive rocks cut across the slates in jagged and irregular lines, but in nearly all cases the lateral pressure, resulting in the bending of the slates, is extremely well marked. Practically no evidence of assimilation on a large scale in this region was obtained.

Fred. E. Wright,
Secretary

THE PHILOSOPHICAL SOCIETY OF WASHINGTON

The 631st meeting was held on March 16, 1907. Dr. L. A. Bauer read a paper on "The Relation between 'Potential Temperature' and 'Entropy.'"

The purpose of this paper was to show the precise relationship between von Helmholtz's term 'waermegehalt' used incidentally by him in connection with his investigations 'On Atmospheric Motions' or of the alternative term 'potential temperature' suggested and used by von Bezold in his papers 'On Thermodynamics of the Atmosphere,' and entropy. It was found that a simple relation existed so that for certain thermodynamic problems the second law of thermodynamics, or the principle of the increase of entropy, could be easily and directly expressed in terms of potential temperature. For these cases whenever the entropy increased during the carrying out of a thermodynamic process, the potential temperature was likewise accompanied by an increase. This was shown by application to certain well-known typical cases of natural, or irreversible processes, *e. g.*, free expansion of gases and heat conduction.

The second paper of the evening was presented by Mr. W. W. Coblentz, upon 'Selective Reflection of Minerals and Lunar Constitution.'

Throughout the spectrum from the ultraviolet into the remote infra-red, various substances show bands of selective absorption and selective reflection. Experiments made to determine whether these bands are due to chemical composition, to molecular weight or to the arrangement of the atoms in the molecule, have always given more or less contradictory evidence; and especially as to the effect of molecular weight. Only recently had the speaker been able to account for most of the contradictions.

From various considerations one would expect to find the bands to shift to the long wave-lengths with increase in molecular weight. It was known that certain groups of atoms cause certain absorption bands, but no shift in the maximum of the band could be detected when the number of groups of atoms was increased in the molecule. The contradiction lies in the failure to make a distinction between the effect of the groups of atoms which is to *cause* the absorption and the reflection bands, and the effect of joining these groups of atoms to various elements (different atomic weight) which have now been found to determine the *position* of the bands. By studying the transmission and reflection spectra of a homologous series of compounds it was found that the position of the characteristic band shifts toward the long wave-lengths, with increase in the molecular weight of the metallic element to which the group of atoms is united to form the compound. These bands lie in the region of $4.5\,\mu$ and $6.5\,\mu$ (transmission) and $8.7\,\mu$ to $9.1\,\mu$ (reflection).

The silicates are exceptions to all the rules, for there seems to be no regularity in the reflection bands, indicating that the grouping of the atoms of oxygen and of silicon is different in the different minerals studied.

When energy is reflected from a plane smooth surface it is commonly called 'regular' (or less accurately 'specular') reflection, while energy reflected from a rough surface suffers 'diffuse' reflection. The reflecting power, R, of any substance is related to its index of refraction, n, and its absorption coefficient, k, by the equation:

$$R=\frac{(n-1)^2+k^2}{(n+1)^2+k^2}.$$

For 'transparent media' or 'insulators' the absorption coefficient is almost zero and the reflection power is a function of only the refractive index. Here the reflecting power is low, only 4 to 6 per cent., and decreases with increase in wave-length. For metals, 'electrical conductors,' the absorption coefficient has become so large that nearly all the energy, for all wave-lengths, is reflected (90 to 98 per cent.).

For substances having selective absorption, when the coefficient of absorption, k, attains the high values the heat or light waves no longer enter the substance, but are almost totally reflected as in the case of metals—whence the name, 'bands of metallic reflection.' If, then, the eye were sensitive to heat waves, many substances would have a 'surface color' similar to that of gold and fuchsine in the visible spectrum. Furthermore, substances having selective absorption (and reflection) will have a low reflecting power in the region where the absorption coefficient, k, is small. In other words, the reflecting power of plane surfaces ('regular reflection') of substances ('transparent media,' 'electrical insulators') having selective absorption, will be low for all regions except where there are bands of 'metallic reflection.' It is evident that a rough surface of the same material will behave similarly, *i. e.*, it will likewise be selectively reflecting.

The speaker found that the silicates have a low reflecting power, 'practically zero,' for the region of the spectrum up to $8\,\mu$ followed by bands of metallic reflection from $8.5\,\mu$ to $10\,\mu$.

It was pointed out from the curves exhibited that a surface such as the earth or the moon if composed of silicates will have bands of strong selective reflection. If, then, one were to examine the heat spectrum of a planet which shines by reflected light, and if its surface is composed of silicates, one would expect to find bands due to selective reflection. By comparing these bands with those of known substances, the composition might be determined. In the case of the moon this is practically impossible on account of the weakness of the radiation to be measured. Atmospheric absorption, and the fact that, in the case of the moon, the maximum of its proper radiation lies in the region of the reflection bands of the silicates, will interfere with the observations. But there is still another complication in that the lunar radiation curve can not be smooth and continuous (as some writers seem to think) if the surface is composed of silicates, because in the regions of selective reflection the emitted energy will be

suppressed, *i. e.,* there will be emission minima where there are reflection maxima (Aschkinass, Rosenthal). But the radiation from the moon can not be detected except when it is illuminated by the sun. The result is that if the surface is composed of silicates, then the observed energy curve will be the composite of the selectively emitted energy of the moon, and the selectively reflected energy of the sun. The selectively reflected energy of the sun will to a certain extent fill up the minima in the lunar emission curve. Atmospheric absorption will decrease the intensity of the radiation, so that it is almost too much to hope to study the composition of the various parts of the lunar surface by the identification of the selective reflection bands in its energy spectrum.

R. L. FARIS,
Secretary

CLEMSON COLLEGE SCIENCE CLUB

THE regular meeting of the club was held on the evening of January 18, at which time Dr. F. H. H. Calhoun gave an illustrated lecture on 'Geological Changes as Factors in Life Development.' The varying relations between the extent of the land masses and the sea was a powerful factor in the life development. When land rose, restricting the habitat of the life of the sea, the weaker ones were compelled to adapt themselves to a different environment or to perish. Again when there was a sinking of the land, the faunæ of the continents were forced to find some avenue of escape for themselves. The various problems which the succession of changes caused were considered in turn, but the main portion of the address was devoted to the development of the vertebrates, especially that of the reptilian dynasty. It seemed less a coincidence that a great geological change was always accompanied by a variation in the flora and faunæ, than that they held the relation of cause and effect.

S. B. EARLE,
Secretary

THE ELISHA MITCHELL SCIENTIFIC SOCIETY OF THE UNIVERSITY OF NORTH CAROLINA

THE 171st meeting was held in the main lecture room of Chemistry Hall, Tuesday, March 19, 7:30 P.M., with the following program:

Professor J. E. LATTA: 'New Developments in Electric Traction.'

Mr. N. C. CURTIS: 'Architectural Composition.'

ALVIN S. WHEELER,
Recording Secretary

THE ST. LOUIS CHEMICAL SOCIETY

AT the meeting of the St. Louis Chemical Society, on March 11, the president, Dr. H. A. Hunicke, opened the proceedings with a brief but feeling encomium on the illustrious chemists, lately passed away in such close succession—Beilstein, Mendeléef, Menchutkin, Roozeboom, Moissan. The society honored the memory of the great ones by rising. Mr. J. J. Kessler presented a paper entitled 'The Chemistry of Electrical Engineering.' Mr. Carl Hambuechen then presented a paper on the cognate subject 'Electro-Chemistry in the Industries.' The latter paper was profusely illustrated with lantern slides.

C. J. BORGMEYER,
Corresponding Secretary

DISCUSSION AND CORRESPONDENCE

THE FIRST REVISER AND ELIMINATION

IF the present discussion of the rules and regulations governing zoological nomenclature shall result in a greater degree of uniformity among the workers in this field, the space that has been devoted to the subject in the pages of SCIENCE will not have been wasted. Few things have resulted so injuriously to the best interests of natural history as the lack of uniformity in regard to the names employed by different writers, following the radical difference in their methods of procedure.

Even at the present time, however, it appears that certain writers in our midst have not a clear idea of the method of elimination as applied to the settling of the question of the true type species of the earlier genera, apparently laboring under the mistaken impression that it is distinct from, or even opposed to, the first reviser method. As a matter of fact, *it is an integral part of this method.* Thus, the author who first elim-

inated one of the original species from the old genus must be considered as a first reviser, since he thereby restricted the limits of the old genus. In like manner the author that subsequently eliminated one of the species from the restricted genus must also be considered a first reviser, and so on down the line. Where the old genus originally contained only two species, neither of which had been designated its type at the time the first reviser eliminated one of them as the type of a new genus, he thereby caused the remaining species to become, by elimination, the type of the old genus, although he did not so designate it. Elimination, therefore, instead of being in opposition to, is in reality a part of the first reviser method.

The action of the first reviser has been upheld by the botanists as well as by zoologists, and is in perfect accord with the fundamental law of priority. Its very reasonableness has commended it to practically all workers in every department of natural history. On the contrary, the first species rule demands that the action of the first reviser be nullified in all those cases where he had designated any other than the first species as the type of the old genus, or had taken the first species as the type of a new genus; it is, therefore, in direct opposition to the first reviser method plus elimination, and also is in opposition to the law of priority. The futility of attempting to force this unreasonable, non-scientific method upon thoughtful, reasoning workers would appear to be so self-evident as to require no further comment. D. W. COQUILLETT

U. S. NATIONAL MUSEUM,
April 3, 1907

POLISHED PEBBLES

TO THE EDITOR OF SCIENCE: On page 392, in the issue of SCIENCE for March 8, 1907, it is stated that wind-polished pebbles from New Jersey are facetted. The wording of the assertion is such as to justify the possible inference that wind-polished pebbles are always facetted. It is doubtless true that in regions where the wind is prevailingly from one quarter, pebbles partially imbedded and held firmly during the polishing process, are usually facetted. On the other hand, where hard unimbedded pebbles and boulderlets lie on the surface of hard rock ledges, fully exposed to strong winds, they become highly polished, but seldom or never show even the slightest tendency to facetting. Facetting can not, therefore, be regarded as an unfailing characteristic of wind-polished pebbles. At White Rock, a few miles east of Boulder, Colo., beautifully polished quartz, quartzite and other pebbles lie by thousands on the wind-eroded surface of the Laramie and Fox Hills sandstones, but probably a day's search would not secure a single pebble showing the slightest suggestion of facetting. A few miles southwest of Villa Grove, in the same state, on a hill of Carboniferous limestone, perfectly polished pebbles are plentiful. No lapidary could do more perfect work, but facetting is not found. These are not gastroliths.

A very interesting discovery of polished pebbles was made by Mr. Philip Argall, of Denver, in the Santa Eulalia mining district, Chihuahua, Mexico. In one of the mines on Santa Eulalia Mountain, the shaft penetrating the massive Cretaceous limestone cuts a fissure leading to a chimney lined with low-grade ore. At the bottom of the chimney, at a depth of 1,200 feet below the surface, there is an elliptical cave-like opening thirty by fifteen feet. The bottom of the cave was plentifully strewn with perfectly polished flint pebbles which were cemented to the calcite-covered floor like plums. In other places the pebbles were found in pot-holes in the underground water courses. The history of these pebbles is believed to be as follows: The deposition of ores was followed by a period of solution during which the caves were formed, and the limestone in places rendered open and sponge-like by solution. The walls and floors of some of the openings were covered with calcite, deposited largely from standing water. Where calcite was not deposited, the solution of the limestone has left nodules of flint standing out from the walls of the caves. Similar nodules loosened from the limestone by solution and otherwise, have furnished the material for the polished pebbles of the caves and water-

courses. The polishing was accomplished by movement in the water-courses, aided by the carbonic acid and the calcium carbonate carried in solution. (The polishing work of such waters may be seen in certain caves in the Copper Queen mine at Bisbee, Ariz.)

The topography of the region, the character of the pebbles, their depth below the surface, their relation to the water-courses, the smallness of the joint openings at the surface and the absence of similar pebbles on the surface all make it improbable that the pebbles came from the surface.

R. D. George

SPECIAL ARTICLES

UPON THE TEACHING OF THE SUBJECT OF RESPIRATION[1]

At least three totally distinct definitions of the term respiration are expressed or implied in current literature. These and varying shades of meaning are often confused even in the same discussion, and the result is very unsatisfactory.

The first definition occurs in works upon the physiology of the higher animals. Among the different senses in which respiration is there used, one refers to the functions of lungs and gills, processes essentially secondary and which take place far away from the cell.

A second definition is found in general works and especially in botanical ones, namely, that respiration is an exchange of gases, a sort of commerce between the cell and its environment. A majority of our botanical text-books give a categorical definition something as follows. "Respiration is the taking in of oxygen and the giving out of carbon dioxid and water." To this is often joined the idea that the amount of carbon dioxid given off is equal to that of oxygen absorbed, that in fact the oxygen which enters is the same as that which reappears immediately as carbon dioxid, and not seldom, some emphatic and sweeping statement that the living substance must obtain oxygen somehow all the time.

A third and entirely distinct meaning is given to the word in more scientific works such as Pfeffer and in at least two American text-books, namely, that respiration is a vital operation taking place within the cell, a metabolic process in which energy is released and which is ordinarily indicated by the gaseous exchange mentioned in the last definition. The steps of this process are not well known, but any discussion of them seems to include also anaerobic or intramolecular respiration and certain kinds of fermentation.

The confusion in words is inconvenient enough, but there is back of it a confusion of ideas which is more serious, and by which the teaching of the subject is more or less impaired. From the standpoint of the teacher it is imperative that the subject be cleared up somewhat. However, before dealing with the appropriateness of definitions, let us briefly look over the phenomena which we have to deal with. The most common forms of apparatus used by teachers in this country in the study of respiration are U tubes or thistle tubes in which flowers or germinating seeds are placed. The end holding the seeds is sealed and the other end placed in some reagent which will absorb carbon dioxid or oxygen, or both, or in mercury which will absorb none of the atmospheric gases and serve as a control. With such arrangements it is easy to obtain satisfactory and instructive proof that oxygen is absorbed and carbon dioxid given off. If the idea were carried no further all would be well, but there is a temptation to bring in also quantitative results, and, pointing out the fact that caustic potash rises about one fifth of the volume of the tube, to imply that the oxygen contained has been combined in the activity of the plant into an equal amount of carbon dioxid. Remarkable quantitative result is it not, that if in an enclosed space there is a plant absorbing oxygen and a reagent absorbing carbon dioxid, the result should be a reduction of volume to that of the nitrogen present?

Ordinary experiments and bright pupils are a combination which is likely to cause a disturbance in formal ideas of respiration. Suppose, for instance, that three U tubes with germinating peas in the sealed end are set up,

[1] Read before the Botanical Society of America at the New York meeting, December, 1906.

the open ends being in pyrogallol, caustic potash and mercury, respectively. The pryo rises rapidly by absorption of oxygen till it occupies about one fifth of the volume, the potash slowly does the same as the plants absorb the oxygen and give off carbon dioxid till it also reaches the one-fifth mark and the mercury does not rise at all. After some days the experiment looked upon as a perfect success is ready to be taken down. Theoretically, over the mercury also the oxygen has been absorbed and its place taken by carbon dioxid. Some student, not knowing any better, concludes to demonstrate that fact by introducing potash solution through the mercury. At once the mercury begins to rise in the tube, carrying the potash before it. The student watches to see it stop at the one-fifth mark and is astonished to see it continue to mount until it has reached two fifths or even more. Then the best the teacher can do is to clumsily explain that here is something he had not meant to demonstrate; that this is *intramolecular respiration,* that carbon dioxid has been produced in quantities and that the mixture of carbon dioxid and air has bubbled out through the mercury, some of the nitrogen thus escaping. Now it will at once be urged that some other seeds than peas should have been used for the experiment. But one may at least inquire why. Peas are living things and they are convenient. Moreover, if seeds in any considerable bulk are employed over mercury, the teacher must choose the seeds very carefully indeed if the idea of an equal exchange is not to suffer. If a series of objects are used, alterations of volume will occur in nearly all. In chrysanthemum flowers and peas the volume increases. In beet, turnip and timothy seed the volume diminishes. Facts such as these have long been known. It is well known, for example, that in oily seeds generally, oxygen absorption at first outruns production of carbon dioxid. Now after such a brief and fragmentary consideration of the experimental side, let us take up the question of definitions.

In regard to the first definition (that respiration refers to the functions of lungs and gills) it may be merely noted that it is of application only in the case of differentiated animals and the question of use must therefore be left to students in that field. It may be pointed out in passing, however, that respiration in this sense is so firmly imbedded in literature that it will probably retain the meaning it has, and that this meaning is so distinct that it will be little source of confusion. For the botanist the discussion must be between the following definitions and here confusion of thought arises very easily.

In regard to the second definition (that respiration is taking in oxygen and giving out carbon dioxid) it may be observed that it is easy of demonstration and is remarkably clear of statement and these features have probably given it its wide currency. But when we press for the conception lying back of the definition, for the idea which the words convey, it seems to be little more than a physical process of diffusion. On this account a telling objection can be raised. Granting that the gaseous exchange is easy to demonstrate and that the definition is exceedingly clear, which the writer is freely willing to do; granting that only aerobic respiration need be referred to in general teaching, which the writer is unwilling to do, it is still open to the fundamental criticism that it turns the student's attention away from the vital and really important process to a superficial and physical one. For far and away the most important idea in the teacher's subject matter is this: The living substance must have energy; it can get it only by working changes in the compounds within reach in such a way as to release energy. If oxygen is at hand these changes are largely those of oxidation. If oxygen is lacking the cell will find another way. To define respiration then as a gaseous exchange is to turn away from the all-important process. In this connection it may also be noted that to imply in addition that the carbon dioxid produced is equal to the oxygen absorbed amounts to positive error as does also the hard and fast statement that all living matter must obtain constant supplies of oxygen.

In regard to the third definition it may be observed that it refers to processes which are somewhat obscure and which are, after all,

covered by the term metabolism. Nevertheless, it points to the really important vital process and it is broad enough to be in harmony with all the facts we know. (If respiration is taking in one gas and giving out another, 'intramolecular respiration' is an absurdity in words.) There seems scanty warrant for the custom of setting aside anaerobic respiration as though it were something entirely different or pathological or unusual. That aerobic and anaerobic respiration and even fermentation are closely connected, has for some time been recognized and has been brought out with especial clearness by Barnes.[2]

It may be urged that respiration in this sense is too abstract and complex to be a profitable subject for general teaching. With this view the writer does not agree. Certainly no amount of obscurity or complexity in an essential process can warrant the adjustment of definitions and teaching so as to lay the emphasis on the superficial accompaniments of that process. It seems to him that fundamental conceptions are the very ones to strive for in general teaching. Teaching may not go very far, but it ought to point in the right direction.

The suggestion made by Barnes[3] that a new term 'energesis' be adopted would be an admirable one, but the word respiration has so long been prominent that it seems unlikely that it will ever be permanently associated with a minor meaning. Moreover, as already stated, some of the best authorities already use it in referring to the metabolic process of energy release. For these reasons the writer thinks it probable that this third definition is the one which will stand. If this opinion is well founded, it becomes the duty of teachers to adopt the latter definition forthwith. Whatever is done, the vital process is to be kept in the foreground in teaching.

The subject of respiration certainly deserves a more adequate treatment in our courses. The writer knows as well as anyone that topics are many and hours are few, but are there not subjects in all our courses that might better be omitted than a fair consideration of a process which is essential and universal? Fundamental ideas penetrate the student's mind but slowly, and the writer feels that two or three experiments on the great question of respiration are not too many. After an experiment of some kind bringing out clearly but only quantitatively the fact that oxygen is absorbed and carbon dioxid given off, let another be set up which shall take some account of quantities—of different phases of respiration. Peas and oily seeds are valuable objects for this purpose. Explanation of the real nature of respiration and of the different kinds of respiration—anaerobic, fermentation, etc., will then follow quite naturally.

When students are using U tubes or thistle tubes there is always a possibility that the sealed end is not perfectly air tight. Eudiometers over mercury are an admirable form of apparatus, for here the question of leakage is removed from discussion, and quantitative readings can be made readily and with accuracy. The seeds are held in the upper end of the tube by glass wool, and in starting the experiment the mercury column is introduced some distance into the tube so that either increase or decrease in volume can be noted. The carbon dioxid evolved can later be directly and accurately measured by introducing caustic potash through the mercury.

After a well-planned series of experiments it is not difficult to question a class till most of them perceive that the various phenomena can be understood only in the light of the fact that in each case energy is set free. The content of the teacher's explanations would then be something as follows: By respiration we understand the changes brought about by the cell whereby energy is released. A supply of energy is a *sine qua non*, for life and reactions which yield energy are universally carried on by living substance. Ordinarily respiration is a process of oxidation, indicated both by an absorption of oxygen and a production of carbon dioxid. A supply of free oxygen seems to be necessary for protoplasmic movement and growth, and for con-

[2] 'The Theory of Respiration,' SCIENCE, February 17, 1905.

[3] *Loc. cit.*

tinued existence in most of the higher plants. The carbon dioxid given off is sometimes equal in amount to the oxygen taken in, but this ratio is a variable one. Most plants are able to respire for limited periods without taking in oxygen. Some of the lower plants are able to do this for prolonged periods—perhaps for a whole life cycle. This phase of the process is called intramolecular or anaerobic respiration and is much the same as certain kinds of fermentation. The steps of the processes of respiration are imperfectly known.

Charles H. Shaw

QUOTATIONS

'NEWSPAPER SCIENCE'

In the last number of Science, a correspondent, dealing with 'fakes and the press,' urges Congress "by some legal enactment to check the publication of all items that convey erroneous impressions relative to matters in which the whole community is interested." The immediate occasion of this somewhat sweeping recommendation is the wide publication late in January of a paragraph to the effect that the Jamaica earthquake, by disturbing the subterranean strata, had increased the flow of oil from the wells of northern Texas and Louisiana, while diminishing that from the southern counties of both states. The tale, it appears, was not true, and certain geologists declared at the beginning that it could not possibly have been true. Nevertheless, the writer is unfortunate in having illustrated his arraignment of 'newspaper science' by an example of a plain 'fake,' which is not typical of 'newspaper science' at all.

If the term has any meaning, it applies not to malicious stock-market rumors, or to wild fantasies which no one would pretend to take seriously, but to the journalistic treatment of matters that have really a scientific status. Just now 'newspaper science' is concerned chiefly with the weight of the human soul. Two days ago some Boston physicians announced that they had demonstrated a loss in weight of from one half ounce to one ounce at the moment of death, or a little later in the case of very slow-witted persons. This morning 'an eminent physiological chemist' adds the information that 'a group of German students' determined years ago that a mouse lost a milligram of weight when it died in an open vessel, but not when in an hermetically sealed bottle. We feel sure that this is not the last, but confidently await the story of the Indiana investigator who found some years ago that the soul of a lizard could be made to keep for years in any climate when contained in a bottle of pink glass. All this will be very interesting, it harms nobody, and at the beginning of the serial story there was some definite information furnished by men of standing.

There is much less guile about newspaper science than the laboratory scientists would have us believe. For instance, last fall, if we may infer causes from results, a newspaper correspondent at a small western lake resort picked up on the beach a defunct specimen of the common 'mud puppy.' He had never seen such a creature before, and took it to a local naturalist, who told him something about its amphibious habits and superabundant breathing apparatus. He also gave the generic name, *Necturus,* which the correspondent or the telegraph operator afterwards misspelled in the account of the monster—its size was a detail not mentioned—which possessed both lungs and gills, four legs, a mouthful of sharp teeth, a long tail, and was 'believed to be the Nocturis.' The finding of a mud puppy would have been no news at all, yet by means of this ingenuous dispatch, some perfectly correct and remarkable bits of scientific information were brought within the reach of a million newspaper readers.

By and large, there are probably quite as many commonplace and elementary scientific facts thus exploited as there are outright fabrications. Set any layman to report the lecture of a scientist who, in going over the field of his own specialty, mingles old with new matter, and he is just as likely to hit upon the former as the latter. If he is looking simply for sensation, he will send out an account, like so many which have emanated from the University of Chicago, bearing very little relation to anything a competent scientist could have

said, but is not likely to have the diabolical ingenuity that sometimes is put into the political 'fake.' The corroborative detail which could give verisimilitude to, say, the story that man is in danger of being ousted by birds from the primacy of the animal kingdom, could only be supplied by the trained scientist, and the trained scientist is above doing such a thing.

A dozen of the colleges are attempting to disarm the unscrupulous journalist by sending out with their own *imprimatur* accounts of the discoveries made by members of their faculties. If this does not drive out the mendacious reporter, the fault can perhaps be justly laid at the door of science herself. Man continues to ask questions about his environment, and to want them answered. Yet it is growing increasingly hard to make real science intelligible. We may instance the perennially interesting sea-urchin eggs of Professor Jacques Loeb. His experiments in developing them covered a long period. Every now and then he established a new point. To the initiated these steps were as distinct as the several equations in an algebraical demonstration; yet to the layman the official accounts of these experiments read so much alike that headline writers hardly attempted to distinguish them, and many undoubtedly thought that the same news was being sent out over and over again. If really epochal discoveries are of such character that they can no longer be described in plain language, the temptation arises to invent discoveries which, though they never really occurred, are perfectly easy to talk about.

Nor, in spite of the scientists' insistence that plain reporters ought not to write about things they do not understand, is the confirmation of a recognized authority a perfect safeguard against the charge of inaccuracy. The *Evening Post* has printed accounts of scientific matters taken down verbatim from the lips of the leaders in particular branches of science, and had them disputed vehemently by other scientists. As the scientific tortoises creep on slowly from point to point, they do not always agree who is ahead; but that, we admit, does not make any less reprehensible the conduct of the irresponsible cottontail who occasionally jumps a few rods ahead of the whole lot.—*The New York Evening Post.*

BOTANICAL NOTES

STUDIES OF TEXAN VEGETATION

FROM time to time it has been a pleasant task of the editor of these notes to call attention to the work of Dr. Bray, of the University of Texas, on the vegetation of his state. The vastness of the territory covered, and the exceedingly varied character of soil, temperature, rainfall and other factors make the task of the botanist one of unusual difficulty. When it is remembered that Texas covers an area nearly as large as the northeastern states from Maine to, and including, Ohio and Virginia, and that north and south its length is about that from Boston to Charleston, and its width east and west about that from Boston to Chicago, one may begin to appreciate the amount of labor involved in what Dr. Bray has already accomplished. He has now added to his previous publications a paper entitled 'Distribution and Adaptation of the Vegetation of Texas,' and published as Bulletin No. 82 of the University of Texas. He tells us that it "was begun under the stimulus of desiring to present to the teachers in the public schools of Texas a point of view from which to study the vegetation of the state." He hastens, however, to say that "the aim is not to supplant other phases of botanical study, but to supplement them," which indicates that the author is not one of those who think that a general observation of the plants of a region, without their particular study, should constitute the content of a course in elementary botany.

The pamphlet, which includes 108 pages (and 14 plates), first takes up the 'Factors of Plant Environment and how they affect Plants,' to which about one half of the space is given, and this is followed by a discussion of the 'Plant Societies of the Texas Region.' In the first the rôles of water, temperature, light, the atmosphere, soils and biological factors are discussed clearly and helpfully. For it must be borne in mind that the purpose of the publication is to help teachers and

others who need help, and this is the key to the treatment throughout its pages. The second general topic includes woodland vegetation, grassland vegetation, desert vegetation, water vegetation, salt-water vegetation, the vegetation of alkaline soils, and sand vegetation. Here again the author has made a very clear statement of the subjects taken up, and no teacher will find much difficulty in following and applying his discussion. The pamphlet should prove of great value to the teachers and pupils in the schools and colleges of Texas.

GARDNER'S STUDIES OF THE CYANOPHYCEAE

In the November number of the University of California Publications Nathaniel L. Gardner publishes an interesting paper on the blue-green algae under the title 'Cytological Studies in Cyanophyceae,' in which he reviews the work of previous investigators, and adds many observations of his own. He refers to his good fortune in being located where there is an abundance and variety of material at all seasons of the year, yielding him over one hundred species which he has collected and studied. In his investigations he has been very ingenious, as when he separates Oscillatorias and related forms from sand by making use of their motility, the threads 'crawling' out of the débris and this giving him pure cultures with little difficulty. He devised also an ingenious method of getting end views of *Oscillatoria* cells without having to make microtome sections. This is done by killing the plants in a strong solution of iodine in potassium iodide (ten to thirty minutes) and then washing in 95 per cent. alcohol (ten to thirty minutes). If now the filaments are mounted in water and subjected to a slight rolling pressure under a cover glass the cells will separate and fall over, giving excellent end views. Ten pages are given to a comparison of the conclusions reached by different investigators, notably Schmitz (1879), Kohl (1903), Phillips (1904) and Olive (1904), and this is followed by a discussion of cell contents, including the nucleus (for these plants have a nucleus of a simple kind), the granules and the cytoplasm. Some studies were made of the products of assimilation, resulting in finding glycogen, but not starch. Finally he finds much similarity between the *Cyanophyceae* and certain bacteria. A helpful bibliography, and six beautiful plates, mostly colored, close this important contribution.

SHORT NOTES

With the January number the *Plant World* enters upon the tenth year of its existence. The business management is changed, the place of publication being Denver, Colorado, and there have been some changes in the editorial management and policy. On the title-page the subtitle has been changed to read 'A Magazine of General Botany' instead of 'Popular Botany.' The purpose of the journal remains unchanged, namely to present botany in a non-technical form, for general readers, students and teachers. Professor Lloyd, now of Tucson, Arizona, continues as managing editor, and Miss Bracket, assistant editor. The other members of the editorial staff are members of the staff of the Desert Botanical Laboratory, and the Arizona Experiment Station. It is likely, therefore, to have a distinctly western flavor, and may thus appeal to a much larger constituency. There is a place for a journal of this kind which will be helpful to the beginner and the young teacher, and which at the same time will be full of information as to botanical matters. It must be suggestive and helpful in regard to the many details in the work of student and teacher, yet in order to be a mere day-by-day guide, it must do more for its readers, by leading them into broader and higher fields of thought and activity.

The twenty-fifth Heft of Engler's 'Pflanzenreich' is devoted to a monograph by Fr. Buchenan, of the Family *Juncaceae*, and makes a volume of nearly three hundred pages. The first thirty pages are given to an introduction in which structure is especially emphasized, with paragraphs on geographical distribution, relationship, uses, etc. Eight genera are recognized, viz.: (1) *Distichia* (3 South American species), (2) *Patosia* (1 Chilian species), (3) *Oxychloe* (2 South

American species), (4) **Marsippospermum** (3 South Pacific species), (5) **Rostkovia** (1 Antarctic species), (6) **Prionium** (1 South African species), (7) **Luzula** (61 species, widely distributed), (8) **Juncus** (209 species, widely distributed). The monograph is illustrated by 121 cuts in the text, including approximately four hundred individual figures.

Professor Doctor B. L. Robinson's address on 'The Problems of Ecology,' given at the Congress of Arts and Science, during the Exposition at St. Louis, 1904, has been reprinted as a twelve-page pamphlet. In speaking of Ecology he closes with these significant sentences: "Dealing as it does with the vital relations of plants to their surroundings, it yields information of the highest importance to the farmer, nurseryman and landscape gardener. Indeed it bridges just that all too wide gap between theoretical and applied botany, connecting the abstruse fields of plant anatomy, plant physiology and classification with the concrete applications of botany in agriculture, horticulture and forestry. The ecologist will never lack that wonderful stimulus which comes to the investigator who is conscious that his work is important to the welfare of his fellow beings, and intimately bound up with human progress."

THE NORTH AMERICAN FLORA

LAST October Part 1 of Volume 7 of the 'North American Flora' was received by subscribers for this work. It was devoted to the *Ustilaginales* (smuts) and was from the hand of Dr. G. P. Clinton, a specialist in this group of plants. Two families (*Ustilaginaceae* and *Tilletiaceae*) were monographed, the first containing 11 genera and 133 species, and the second 8 genera and 78 species. We have now another part (part 2) of the same volume, continuing the paging from 83 to 160, and devoted to the *Uredinales*. This part is by Dr. J. C. Arthur, who is well known as the foremost American student of the rusts, and whose contributions have often been noticed in these columns. He divides the order into three families (*Coleosporiaceae, Uredinaceae* and *Aecidiaceae*), the first and second of which are completed, the third (and much the largest) being broken off near the end of the fourteenth of its thirty-seven genera. The author follows the general outline given by him in a paper presented at the International Botanical Congress at Vienna last year, with some modification, however. A fuller notice is reserved until the completion of the monograph.

The four parts now published enable subscribers and others to get some idea of the bigness of the undertaking on the part of Dr. Britton and his colleagues to bring out a complete flora of North America. These parts average 88 pages each, and they have appeared at intervals which average about seven months in length. At this rate none of us would live to see the completion of the great work, but it is to be supposed that the parts will soon begin appearing at much shorter intervals. In the meantime it is evident that every working botanist, and every department of botany in every college and university, will have to become a subscriber to this greatest systematic work ever projected for any country.

CHARLES E. BESSEY
THE UNIVERSITY OF NEBRASKA

THE NEW CHEMICAL LABORATORY OF THE RENSSELAER POLYTECHNIC INSTITUTE

THE building is of four stories, and built of Indiana limestone and Harvard brick with roof of copper. It is entirely fire-proof, the partitions being of hollow brick, plastered, and the floors of concrete with a terrazzo finish. The woodwork trimmings of doors, windows and cases are of oak. The framework of the building is of steel construction. The staircases are of iron with treads of Tennessee marble. The hallways are tiled up to seven feet from the floor with 3 x 6 white tile, the baseboard being of Tennessee marble. The windows are very large and the glazing is of plate glass.

First Floor.—Assay Laboratory (54 x 52 ft.). This laboratory furnishes desk accommodation and furnace room for seventy-four students at once, which is the largest fire-room accommo-

dation in the country. The furnaces consist of eighteen large muffles for scorification and cupellation and fourteen pot furnaces for crucible work. Each furnace has a separate flue. The students' desks are topped with an inch and a half slab of Alberene stone and each contains drawers for the accommodation of apparatus. The supporting legs are of iron. Water is supplied at the ends of the rows of desks, where are situated sinks of Alberene stone. The other furniture of the laboratory consists of anvil blocks, tables for bucking plates, ore-crushers and racks for cooling crucibles.

Quantitative Laboratory (44 x 16 ft.). This laboratory has accommodations for twenty students at a time in quantitative analysis. It is excellently lighted. The students' desks are topped with Alberene stone supported upon iron supports and containing four drawers for apparatus, with storage room below each desk for larger pieces. The large hood accommodation is provided with hot plates and water bath, the hoods being made of angle iron painted with aluminum paint and are glazed with corrugated glass. Water is supplied in sinks of solid porcelain. Gas, air blast and suction are also at hand. A special weighing room (7 x 16 ft.) opens off this laboratory, where the balances are supported on Alberene stone bracketed to a brick wall of especially heavy construction. Next to this balance room is a second balance room similarly fitted up and containing the assay balances for the students in the assay laboratory.

Instructors' Room (19 x 13). This room opens both into the assay laboratory and into the quantitative laboratory and is fitted with hood, water, blast, suction and the other requisites for a complete private laboratory for the instructor in that department. It is also arranged to accommodate the supplies of materials issued to students as examination topics in both the courses over which it has control.

The Stock Rooms are four in number (9 x 16, 12 x 26, 9 x 16, 5 x 16) and are fitted with appropriate shelving to accommodate the chemicals and apparatus required for general laboratory purposes.

The Sulphuretted Hydrogen Room (8 x 6) is ventilated by special device directly into the open air and contains the sulphuretted-hydrogen apparatus from which the gas is piped to the thirty-six outlets in the main qualitative laboratory on the floor above. The gas is delivered under a pressure of about ten inches of water.

Fuel Bins (11 x 8), for the coal and coke necessary for the assay laboratory, are arranged so as to permit the fuel to be shot through coal-holes in the roof, which is on the level of the roadway above.

Second Floor.—Main Qualitative Laboratory (50 x 80 ft.). This room is lighted by large windows on four sides and by a skylight extending over half its area. On each end are the hoods made of metal and glass, eight in number, and each 6 feet in length, making a total hood accommodation of nearly 100 linear feet. These hoods contain the hot plates and the steam baths for boiling and evaporation and they also contain the thirty-six outlets wherefrom students can secure sulphuretted-hydrogen gas for purposes of precipitation. The steam baths are two in number, with accommodations for fifty steam evaporations at once, the steam being admitted to chambers of Alberene stone directly from the steam pipes of the heating system. Each hood has its own individual outlet flue for fumes. The laboratory has accommodations for one hundred and thirty students at a time in qualitative analysis. Students' desks are topped with Alberene stone and are furnished with four drawers and two closets for apparatus. Water is supplied to each desk and the sinks are of solid porcelain. Each student is provided with forty reagents in glass bottles which are supported by shelves of plate glass resting upon metallic uprights. The heating of this laboratory, as of all other rooms in the building, is furnished from the steam plant in the department of electrical engineering. Radiators are everywhere placed under the windows, and in addition to the heat so supplied a further quantity is furnished by the ventilation system. Air is sucked in from the outside, passed over heated steam

coils, and is then blown by an electric fan through ducts opening in the side walls of the laboratory. Fumes pass out not only through the individual fume flues of the hoods, but also through numerous flues opening a little below the ceiling along all the walls. These flues have also openings near the floor, so that either opening may be used as occasion demands. Spectroscope accommodations are furnished in the four corners of this laboratory. One feature worthy of notice is the broad eight-foot aisles between the lines of desks. This gives abundant room to every student.

Supply Room (6 x 16). This room is of two stories and is intended to be used for the issuing of reagents and as a storage room for smaller glass apparatus.

Instructor's Room (12 x 16). Because of the great height of its ceiling this room has a gallery around two sides, thus greatly increasing the storage space for chemicals, because of the increased wall space for shelving. The distilled-water apparatus is here located and the supply of distilled water is here stored in a tin-lined copper tank, the water being tapped off therefrom to a spigot in the main laboratory. The room is equipped with complete apparatus suitable for a private laboratory.

Ward Room (10 x 16). Fitted with the usual accommodations for receiving hats and coats of the students.

Organic Combustion Room (8 x 16). This room is fitted with Alberene stone tables, gas, blast and suction and is arranged to receive the combustion train for the usual work in organic combustion.

Third Floor.—The Lecture Room (50 x 41 ft. 6 in.) has seating accommodations for two hundred men. It contains the large lecture table with pneumatic trough and the other essentials to fit it for lecture uses. It is lighted by three small and six very large windows. On the wall opposite the lecture table there projects a gallery intended to hold the electric lantern for illustration work. This gallery is entered from the floor above.

Private Laboratory (16 x 24). This room is fitted as a private laboratory for the professor of chemistry and contains the usual complement of heeds, water baths and other appliances suitable to such use.

The Laboratory for Gas Analysis (11 x 16) contains Alberene-stone table, water, gas and blast accommodations, with suitable shelving to accommodate the apparatus for which the room is intended to be used.

The Special Laboratory (10 x 16) is fitted in the same manner as that of gas analysis and is intended to be used for such special work as the examination of food products, etc.

Fourth Floor.—Water Laboratory (20 x 31). This laboratory is fitted with Alberene-topped tables and with water appliances suitable to the very complete examination of questions dealing with the examination of potable, mineral and boiler waters. Appliances are here established for undertaking such examinations from both the chemical and the bacteriological sides. An especially devised table for the determination of free and albuminoid ammonia permits of the analysis of six waters at once. Suitable provision is made for the sterilizers, incubators and other apparatus peculiar to a water laboratory.

Section Room (20 x 20). This room is fitted with blackboards and is intended for use as a recitation room in chemistry. It has accommodations for a section of about twenty-five men at a time.

The Halls.—The halls throughout the building are eight feet in width.

Lighting.—The building is piped for gas, but it is as a precaution only, inasmuch as electricity is to be depended upon for lighting purposes.

W. P. MASON

ALLAN MACFADYEN

AT the early age of forty-six years Dr. Allan Macfadyen has been taken away from his work. By an accident in the laboratory in which he was working a preparation of the serum for Malta fever infected him—the infection seems to have been through the eyes—and death carried him away. Professor Macfadyen was educated in Edinburgh and grad-

uated in 1886. Two years later he took his B.Sc. and then studied abroad at Berne, Göttingen and Munich. There he flung himself upon laboratory methods and bacteriology and in 1889 became professor of bacteriology in the College of State Medicine in London. He was associated with Lord Lister, Sir Joseph Fayrer and others in the inception and foundation of the Jenner Institute and was himself director of the institute. Under his direction the new and splendid laboratories were built at Chelsea. That institute is now known as the Lister Institute and into it Dr. Macfadyen built some of the best years of his life.

But that which will give him a permanent place, according to the London *Lancet,* in the history of science is his experimental work on the intracellular toxins of bacteria with which his name is so intimately associated. His many valuable papers to the Royal Society and scientific journals, English and German, testify to his activity in the investigation of important matters relating to preventive medicine. They run over a wide range of subjects, but by far the most important, as they will probably be the most enduring, are his studies on the intracellular toxins. After resigning his position at the Lister Institute, where his persistence in this line of research was, we must suppose, unappreciated, although it had the support of Lord Lister, he pursued his investigations at King's College and at the Wellcome Laboratory. Concerning his work there a friend writes: "Macfadyen's view was that serum therapeutics had reached an impasse, owing to the great difficulty of producing efficient antibodies for intracellular toxins, and he made a profound study of the delicate and volatile nature of the most active toxins and the destructive effect of heat and other agents upon most of them. He had prepared from the endotoxins of the bacilli of typhoid fever, cholera, pneumonia and other diseases serums of higher antitoxic power than had ever been obtained before. At the time when he became ill he had succeeded in his anticipation with the plague endotoxin and was working also at Malta fever. He expected to have brought to completion in the course of three or four months a research which had engaged his attention for years and which would have brought the sera into use. His anti-typhoid serum has already begun to be employed in some of the London hospitals. But, alas, it was not given to him to finish his work."

Dr. Macfadyen had made a reputation for himself as a popularizer of science. In his lectures before the Royal Institute he attained a distinct success as a public speaker. He was married to Miss Marie Bartling, the daughter of Professor Bartling, director of the Botanical Gardens at Göttingen. He leaves a widow but no children. Many of his pupils are in Canada and in this country and from all over the world expressions of sympathy have been received from those who worked with him in his laboratories at Chelsea.

GOVERNMENT APPROPRIATIONS FOR SCIENTIFIC PURPOSES FOR THE FISCAL YEAR ENDING JUNE 30, 1908

THE following list of appropriations for the fiscal year ending June 30, 1908, for the government scientific bureaus has been compiled from the various congressional appropriation acts. It is not an official summary such as will appear later in the digest of appropriations published by the division of bookkeeping and warrants of the Treasury Department.

Besides the bureaus included in this list are a number of departmental interests which involve the direct application of science in one form or another. Under the Treasury Department, for instance, the supervising architect's office, the office of the director of the mint, and assay offices, the bureau of engraving and printing, and the whole of the public health and marine hospital service, are in a sense bureaus of applied science. So, too, under the War Department, the office of chief of engineers, the bureau of ordnance, the signal office, and the surgeon general's office, and under the Navy Department, the bureau of steam engineering, the bureau of ordnance, and the bureau of medicine and surgery might be called scientific bureaus. The lighthouse board of the Department of Commerce and Labor, and the Indian office and bureau of education of the Interior Department, are

sometimes included among the scientific bureaus.

The list of appropriations for scientific purposes is as follows:

UNDER THE TREASURY DEPARTMENT

Hygienic Laboratory, Public Health and Marine Hospital Service	$90,000 00

UNDER THE NAVY DEPARTMENT

Hydrographic Office	$141,500 00
Naval Observatory	62,390 00
Nautical Almanac Office	21,240 00

UNDER THE INTERIOR DEPARTMENT

Patent Office	$1,288,150 00
Geological Survey	1,476,420 00

UNDER THE DEPARTMENT OF COMMERCE AND LABOR

National Bureau of Standards	$189,620 00
Coast and Geodetic Survey	992,316 40
Bureau of Fisheries	702,760 00

UNDER THE DEPARTMENT OF AGRICULTURE

Weather Bureau	$1,413,540 00
Bureau of Animal Industry	1,032,480 00
Bureau of Plant Industry	1,052,230 00
Forest Service	2,400,000 00
Bureau of Chemistry	697,920 00
Bureau of Soils	206,980 00
Bureau of Entomology	136,010 00
Bureau of Biological Survey	52,000 00
Office of Experiment Stations	1,013,220 00
Emergency Appropriations:	
Cotton boll weevil investigations	190,000 00
Prevention of spread of gypsy and browntail moths	150,000 00
Eradicating cattle ticks	150,000 00
Special Appropriations:	
Survey of Appalachian and White Mountain watersheds	25,000 00
Agricultural colleges, to each state and territory	5,000 00
Total for the Department of Agriculture, including building and deficiency appropriations	9,698,590 00

UNDER THE SMITHSONIAN INSTITUTION

International Exchanges	$ 32,000 00
American Ethnology	43,000 00
International Catalogue of Scientific Literature	5,000 00
Astrophysical Observatory	13,000 00
National Museum	250,080 00
National Zoological Park	110,000 00
Final appropriation for the new building for the National Museum	1,250,000 00
Total under the Smithsonian Institution	1,703,080 00

MISCELLANEOUS

Government Printing Office, printing for scientific bureaus	$824,450 00
Library of Congress	616,885 00
Botanic Gardens	29,893 73
Army War College	24,400 00
Naval War College	19,200 00
Army Engineer Survey of Northern and Northwestern Lakes	75,000 00
Division of Topography, Postoffice Department	47,900 00
Alaskan Seal Fisheries	11,430 00

SCIENTIFIC NOTES AND NEWS

ON the occasion of the dedication of the new buildings of the Carnegie Institution last week, honorary degrees were conferred by the Western University of Pennsylvania on a number of the foreign guests including Sir Robert Ball, Lowndean professor of astronomy and geometry in Cambridge University; Dr. P. Chalmers Mitchell, secretary of the London Zoological Society; Sir William Preece, the British electrical engineer, and Dr. F. S. Archenbold, director of the Treptow Observatory.

THE summer meeting of the American Chemical Society will be held at Toronto, June 27–29. The following persons will act as chairmen of the various sections:

Physical Chemistry: W. D. Bancroft.
Inorganic Chemistry: C. L. Parsons.
Organic Chemistry: J. B. Tingle.
Agricultural, Sanitary and Biological Chemistry: F. T. Shutt.
Industrial Chemistry: W. H. Ellis.

DR. ALEXANDER GRAHAM BELL will shortly go to England to receive the doctorate of laws from Oxford University.

PROFESSOR W. W. KEEN, of Philadelphia, a delegate to the Surgical Congress at Berlin, has been elected an honorary member of the German Surgical Society.

J. M. STEDMAN, professor of entomology in the University of Missouri and entomologist of the Experiment Station, has been granted

leave of absence for seventeen months, which he will spend in study and in travel abroad, and also in research at the Naples Zoological Station.

Sir Philip Magnus, M.P., is engaged in an inquiry for the Cardiff Education Authority with reference to possible improvements in the technical instruction and other branches of education in the city.

The council of the Royal Geographical Society has awarded the Founder's Medal to Dr. Francisco Moreno, who has for twenty years been occupied in exploring South America, especially Patagonia and the southern Andes, and the Patron's Medal to Dr. Roald Amundsen, the Norwegian explorer, who recently completed the northwest passage for the first time in a ship. The Murchison bequest has been awarded to Captain G. E. Smith for his various important surveys in British East Africa; the Gill Memorial to Mr. C. Raymond Beazley for his work in three volumes on 'The Dawn of Modern Geography,' the result of many years' research; the Back bequest to Mr. C. E. Moss for his important researches on the geographical distribution of vegetation in England; and the Cuthbert Peek Fund to Major C. W. Gwynn, C.M.G., D.S.O., R.E., for the important geographical and cartographical work which he carried out in the Blue Nile region and on the proposed Sudan-Abyssinian frontier.

The Tiedemann Prize, awarded every fourth year by the Senckenberg Society at Frankfort a. M. to the German writer who has produced the best work along the lines of comparative anatomy and physiology has been awarded this year to Dr. E. Buchner of Berlin for his researches on fermentation.

On the invitation of President Schurman, Professor Burt G. Wilder, of Cornell University, will give a memorial address on May 28, to commemorate the one hundredth anniversary of the birth of Louis Agassiz.

The Princeton correspondent of the New York *Evening Post* states that Professor Alexander T. Ormond will lecture on philosophical and educational subjects before the Johns Hopkins University, the University of Virginia, the University of Tennessee, Grant University of Chattanooga, Vanderbilt University, the University of Georgia, Tulane University, the University of North Carolina, and the University of South Carolina.

Professor W. P. Bradley, of Wesleyan University, who designed the liquid air plant recently installed for the Sheffield Scientific School, Yale University, lectured on March 21 on 'Liquid Air as prepared and used at the Cryogenic Laboratory of Wesleyan College.'

At the meeting of the Davenport Academy of Sciences on March 30, Professor Herbert Osborn, of the Ohio State University, gave a lecture on 'Eccentricities of Insect Life,' illustrated by a series of lantern slides.

On the occasion of the fiftieth anniversary of his graduation in medicine, Professor Ernst Haeckel of Jena was made a privy medical councilor with the title of *Excellenz*. He practised in Berlin before taking up the work in natural science which made him famous.

The building erected by Mr. Andrew Carnegie for the United Engineering Societies was dedicated this week. On Tuesday afternoon addresses were made, if the announcements of the program were carried out, by Mr. Andrew Carnegie and President Arthur T. Hadley. In the evening there was to be a reception at which the officers of the different societies would receive in their rooms. On Wednesday afternoon addresses were announced by Dr. Samuel Sheldon, president of the American Institute of Electrical Engineers; Dr. Frederick R. Hutton, president of the American Society of Mechanical Engineers, and Dr. John H. Hammond, president of the American Institute of Mining Engineers. The John Fritz medal was to be presented to Dr. Alexander Graham Bell and medals for distinguished services to Dr. Ralph W. Pope and Professor Frederick R. Hutton. Meetings of the societies were to be held on Thursday and Friday.

The American Electro-chemical Society will meet at the University of Pennsylvania on May 2, 3 and 4, 1907.

The College of Physicians of Philadelphia announces that the next award of the Alvar-

enga prize, being the income for one year ($180) of the bequest of the late Señor Alvarenga, will be made on July 4, provided that an essay deemed worthy of the prize shall have been offered.

THE National Museum of Wales has obtained a charter of incorporation.

PLANS and particulars of land for the erection of the new Solar Physics Observatory at Hindhead have been placed before the British Minister of Education.

THE Lake Laboratory of Ohio State University announces for the season of 1907 courses in general zoology, embryology, entomology, ichthyology, ornithology, invertebrate morphology, experimental zoology, vertebrate comparative anatomy, aquatic biology, research work, general botany, ecology and special work in botany. The staff for the season includes, besides the director, Professors L. B. Walton, Ph.D., Kenyon College; Malcolm Stickney, A.M., Denison University; Lynds Jones, Ph.D., Oberlin College; Charles Brookover, M.S., Buchtel College, and W. B. Herms, A.M., Ohio Wesleyan University. The laboratory offers free tables for independent investigators and will welcome any who have problems in biology which can be studied to advantage at the laboratory. The laboratory will be open for instruction courses from June 24 to August 2 and for investigators from June 24 to about September 15. Applications may be sent to the director, Professor Herbert Osborn, Ohio State University, Columbus, O.

THE University of Wisconsin Agricultural Experiment Station is conducting a campaign against the spread of bovine tuberculosis among the 100,000 dairy herds of the state. A bill has just been introduced into the legislature providing for the testing of all cattle before they are sold. The existing laws, providing for the inspection of cattle before they are brought into the state, protect dairymen from infection from outside the state, and the faculty of the college of agriculture is working toward similar protection within the state to prevent the spread of tuberculosis from infected herds to others. Dr. H. L. Russell, of the department of bacteriology of the university, who is also a member of the Live Stock Sanitary Board of Wisconsin, has given instructions in the use of the tuberculin test to 1,200 young farmers from all over the state, former students in the college of agriculture who now compose the membership of the University Agricultural Experiment Association.

Nature gives the following scientific subjects for which prizes are offered by the Reale Instituto Lombardo for the Cagnola prize, April, 1907, on the discovery of radioactivity and its influence on modern physical and chemical theories; for 1908, on the present state of metallography in relation to the physical properties of metals, particularly iron and steel, a general summary including some original results for the Fossati prize for 1907, on the so-called nuclei of origin and termination of the cranial nerves; for the Kramer prize for 1907, a discussion with certain practical applications of Guglielmini's hydraulic theories; for the Secco Comneno prize for 1907, a discovery relating to the virus of rabies; for 1911, on the physiological action of high-frequency currents. As in previous years, other prizes are offered for literary and commercial subjects and for subjects which are the same every year. For the present year the prize awards of the Reale Instituto Lombardo include a Cagnola prize of £100 and medal of value £20 to Dr. Augusto Moschini, of Pavia, for his essay on the pathology of the suprarenal capsules; a prize of £80 to Dr. Guido Sala, of Pavia, and awards of £20 to Professor Domenico Lo Monaco and G. Pitò, of Rome, for essays on the anatomy of the visual centers of higher vertebrates under the Fossati foundation; and Kramer prizes of £80 each to Ernesto Canalli, of Naples, and Mario Baroni, of Milan, for essays on the resistance of structures in cement.

THE U. S. Geological Survey has completed a line of spirit levels through Death Valley, California, and has ascertained that the depth of that area is not so great as was supposed. The final computations of the results have not yet been made, but the preliminary figures give for the lowest point a depth of 276 feet below

sea level. Bennetts Well, which is near this point, is 266 feet below sea level. These figures are probably not more than three feet in error. The Geological Survey now has elevation marks on the highest and lowest points of dry land in the United States. It is a coincidence that these two extremes are both in southern California and only 75 miles apart. Mount Whitney is a foot or two over 14,500 feet above sea level, while Death Valley, as above stated, is 276 feet below. Before the Salton Sink, also in southern California, was flooded by the Colorado River, it contained the lowest point of dry land in the United States, a spot 287 feet below sea level. Previous estimates of the depth of Death Valley based on barometer readings gave for the lowest point figures varying from 250 to 450 feet below sea level.

Nature states that at the annual general meeting of the Geological Society on February 22, Sir Archibald Geikie, the president, described the arrangements contemplated for the celebration of the society's centenary next September. Invitations to attend the meetings will be sent to all the foreign members and foreign correspondents of the society, and geological societies, geological surveys, and learned institutions which have a geological side, will be asked to send delegates. Personal invitations will also be addressed to geologists of note in the old and the new world, who are not already enrolled in the foreign lists of the society. The official program will probably extend over three days in London. The arrangements for each of these three days are under consideration, but Sir Archibald Geikie proposes to give his presidential address as the *pièce de résistance* of one of the forenoon or afternoon meetings. In that address he will offer a sketch of the state of geological science outside Britain at the time when the Geological Society of London was founded, and indicate the external influences that affected its start. By this choice of a subject he hopes to interest the foreign guests, while at the same time inviting the fellows of the society into a domain of the history of science which is perhaps less familiar than it deserves to be. The chronicle of the society itself during the first hundred years of its existence has been carefully and fully compiled from all available sources by Mr. Horace B. Woodward for publication in volume form. Excursions to places of geological note in Great Britain will probably be arranged, some to precede and others to follow the meeting in London. The various museums and places of interest in the metropolis will, of course, be shown to the expected visitors, and there will doubtless be no lack of public and private hospitality. It is anticipated that the Universities of Oxford and Cambridge will both receive the foreign guests.

UNIVERSITY AND EDUCATIONAL NEWS

The Drapers Company has decided to continue its grant of £800 a year for the stipend of the professor of agriculture at Cambridge for another period of ten years. The company has also given £200 for the completion of the astronomical equipment of the University of London.

Mrs. Russell Sage has given $150,000 to the Northfield (Mass.) Seminary for a new chapel and a music building.

The Johns Hopkins University will hereafter admit women to graduate courses in cases where no objection is made by the instructors. Women have been admitted to the medical department of the university since its opening in 1893.

The London University holiday course for foreigners will be held from July 22 to August 26.

It has been decided by the council of the University of Leeds to create a separate chair of botany. This has arisen out of the resignation of Professor Miall, who combined the teaching of botany with zoology.

Dr. W. Peddie, lecturer in natural philosophy in the University of Edinburgh, has been appointed to the Harris chair of physics in University College, Dundee, in succession to Professor Kuenen.